

Vol. 4.

APRIL, 1917

No. 4.

JOURNAL
OF THE
BOSTON SOCIETY
OF
CIVIL ENGINEERS



Published monthly, excepting July and August, by the Society,
715 Tremont Temple, Boston, Massachusetts.

Entered as second-class matter, January 15, 1914, at the Post Office at Boston, Mass.
under Act of August 24, 1912.

Subscription Price, \$4.00 a year (Ten Numbers)
50 Cents a Copy

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14 Beacon Street, Boston

BOSTON SOCIETY OF CIVIL ENGINEERSFOUNDED 1848

PROCEEDINGS

NOTICE OF REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY, APRIL 18, 1917,

at 8 o'clock P.M., in CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Mr. Charles R. Gow will read a paper entitled, "The History and Present Status of the Concrete Pile Industry." The paper will be illustrated with lantern slides.

The Boston sections of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers have been invited to join in the meeting.

S. E. TINKHAM, *Secretary*.

SPECIAL MEETING.**Military Night.**

A special meeting of the Boston Society of Civil Engineers will be held on

WEDNESDAY EVENING, APRIL 11, 1917,

at 7.30 o'clock in LORIMER HALL, TREMONT TEMPLE, BOSTON. (The main entrance, 82 Tremont Street, will be found the most convenient.)

The meeting will be addressed by the following speakers:

Lieut.-Col. W. P. Chamberlain, Medical Corps, U. S. A., on Military Sanitation.

Capt. F. B. Downing, Corps of Engineers, U. S. A., on Organization and Duties of Engineer Troops.

Capt. John F. Osborn, First Corps of Cadets, Mass. National Guard, on the Engineering Instruction now being given in that Corps.

The addresses will be illustrated with lantern slides.

Resolutions will be presented looking to the organization of a corps of engineers as a part of the National Guard of the State of Massachusetts, and also to the organization of a sanitary reserve.

S. E. TINKHAM, *Secretary*.

ANNOUNCEMENT.

An Engineer Regiment for the National Guard.

A regiment of engineers for the Fifth Division of the National Guard (New England) is now being raised by the First Corps Cadets of Boston, an organization which has been in continuous existence since 1741.

The expansion of this corps from a battalion of four companies of infantry to a regiment of six companies of engineers, with the necessary staff and non-commissioned staff, will give opportunity to a large number of engineers to become officers and non-commissioned officers in an organization which promises to become the *corps d'élite* of the National Guard. Twenty officers beside those already in the Corps will be necessary, and a large number of trained enlisted men will be required to bring the new organization up to war strength.

The plan is approved by the Governor, the Adjutant-General and the Militia Bureau, and the two ranking officers of the new regiment will be regular army officers, thus giving promise that the regiment will be given a chance for real service.

This organization will be the first and only engineer regiment in New England, and will be the only complete National Guard engineer regiment in the United States outside of that of New York.

Work with this organization will give the very best opportunity to learn all branches of the military service and thus give

the enlisted men a chance to study for commissions in other branches.

The ranks of the new organization are filling up fast, and there is need for prompt action by those wishing to become identified with the new regiment. Information will be gladly furnished at the armory any day or evening, or on application to Capt. John F. Osborn, 201 Devonshire Street. Regular drills are held every Tuesday evening, and some engineer work is now being done.

What better time can there be for the engineers of Boston to show that they are ready for action, and what organization can better serve as a medium for doing their best work than this new regiment?

The requirements for an officer of engineers can be obtained on application. The following are some of the professions and trades needed for a flexible unit:

ENGINEERS.

Civil	Mining	Bridge
Mechanical	Sanitary	Road
Electrical	Hydraulic	Railroad

TRADES.

Construction foreman	Carpenter	Hoisting engineer
Surveyor	Blacksmith	Locomotive engineer
Photographer	Plumber	Locomotive fireman
Draftsman	Mason	Teamster
Master mechanic	Saddler	Blaster
Dock builder	Horseshoer	Shorer
Telegrapher	Wheelwright	Woodsmen
Lineman	Concrete worker	Iron worker
Electrician	Machinist	Timberman
Pipe fitter	Rigger	

PAPERS IN THIS NUMBER.

"The History and Present Status of the Concrete Pile Industry." Charles R. Gow.

Memoir of deceased member.

CURRENT DISCUSSIONS.

Paper.	Author.	Published.	Discussion Closes.
"Manchester, Mass., Outfall Sewer."	Raymond C. Allen.	Mar.	May 10.
"Extension of the North Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor."	Clarence A. Moore.	Mar.	May 10.

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, MASS., March 21, 1917. — The sixty-ninth annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, at 12.15 o'clock P.M., President Richard A. Hale in the chair.

The reading of the record of the last meeting was dispensed with, and it was approved as printed in the March JOURNAL.

The President reported for the Board of Government the election of the following candidates for membership in the grades named:

Member — Mr. Harold Simpson Crocker.

Juniors — Messrs. Waldo Francis Pike and Henry Connor Sheils.

The Secretary announced the deaths of members of the Society as follows:

William J. C. Semple, died November 10, 1916; Harry C. Foster, died March 5, 1917; Willard W. Wight, died March 10, 1917;

and by vote the President was requested to appoint committees to prepare memoirs.

The committees appointed are: On memoir of Harry C.

Foster, Mr. Frank O. Whitney; on memoir of William J. C. Semple, Mr. Franklin M. Miner; and on memoir of Willard W. Wight, Mr. John J. Van Valkenburgh.

The Secretary presented, for Mr. L. Lee Street, — the committee appointed for the purpose, — the memoir of Lorenzo G. Moulton, which he had prepared. By vote it was accepted and ordered printed in the JOURNAL of the Society.

The annual reports were then presented as follows: The report of the Board of Government was read by the Secretary and by vote was accepted and placed on file.

The Treasurer read his annual report which was accepted and placed on file.

The Secretary read his annual report which was also accepted and placed on file.

The Librarian read the annual report of the Committee on the Library which was accepted and placed on file.

Mr. Henry A. Symonds read the report of the Committee on Social Activities which was accepted and placed on file.

By vote, the appointment of the special committees of the Society was referred to the Board of Government, with full powers.

The tellers of election, Messrs. Nathan S. Brock and Henry B. Wood, submitted the result of the letter ballot for officers of the Society for the ensuing year, and in accordance with their report the President announced that the following officers had been elected:

President — George C. Whipple.

Vice-President (for two years) — Charles W. Sherman.

Secretary — S. Everett Tinkham.

Treasurer — Frank O. Whitney.

Directors (for two years) — Clarence T. Fernald and Lewis E. Moore.

The retiring President, Mr. Richard A. Hale, then delivered the annual address which will be printed in the next number of the JOURNAL.

Mr. Frank A. Marston, one of the committee to recommend the award of the Desmond FitzGerald Medal, at the request of the President, then presented that medal for the year 1916 to

Mr. Dana Melvin Wood, for his paper entitled, "Power Estimates from Stream Flow and Rainfall Data." Mr. Wood in accepting the medal thanked the Society for the honor accorded him in presenting him with this beautiful medal.

Past President Eddy suggested that, in connection with the proposed State Constitutional Convention to be held this year, it might be well to have matters relating to engineering properly presented to that Convention.

He moved, and it was so voted: That matters in relation to engineering coming before the Constitutional Convention, to be held this year, be referred to the Board of Government with power to act.

The meeting then adjourned to partake of the thirty-fifth annual dinner.

During the dinner there was singing by Joseph Ecker.

Before introducing the speaker of the afternoon, the President presented the President-elect, Mr. George C. Whipple.

Mr. Whipple expressed his sincere thanks for the honor which had been conferred upon him, and promised his most earnest endeavors, with the assistance of the other officers who had been elected, to promote the welfare of the Society and the success of the meetings.

Mr. Frank M. Williams, state engineer of New York, was then introduced and gave a most interesting account of the construction of the New York Barge Canal and Terminal Connections. Mr. Williams's address was illustrated with a large number of beautifully colored lantern slides showing the progress of the work, and with motion pictures of the operation of the locks.

On motion of Mr. Eddy, a unanimous vote of thanks was tendered Mr. Williams for his kindness in coming before the Society with his interesting and instructive address. The meeting then adjourned.

In the evening, the "Smoker" was held in the auditorium, the attendance being 325. Light refreshments were served as usual.

A most interesting and enjoyable entertainment was furnished by the White Entertainment Bureau, introducing The

Oxley Troubadours, two Buck and Wing Dancers, Mr. Simmons, entertainer, Mr. Blood, "The Man with the Hat," and Mr. Myer, tenor soloist.

The attendance of members and guests at the various functions of the annual meeting was more than 360.

S. E. TINKHAM, *Secretary*.

ANNUAL MEETING OF THE SANITARY SECTION.

BOSTON, MASS., March 7, 1917. — The annual meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening in Chipman Hall, Tremont Temple. The meeting was called to order at 7.45 o'clock by Vice-Chairman Edward Wright, Jr.

The minutes of the February meeting were read and approved.

The appointment of the committee to study, collect data and report upon the distribution of excessive rainfall in Boston and vicinity was announced as follows: John W. Howard, Edgar S. Dorr, Lewis M. Hastings, Henry A. Varney, Edwin H. Rogers, William L. Vennard, Frank A. Marston.

The annual report of the Executive Committee was read by the Clerk.

Voted that the report of the Executive Committee be accepted and placed on file.

Voted that the recommendation of the Executive Committee be adopted as follows:

That the Board of Government of the Society be requested to consider the advisability of, and if possible bring about the installation of, mechanical ventilating apparatus in the Library, in order that the Section meetings may be held in that room with greater comfort. Also, that a more satisfactory screen be installed for use with the lantern.

A verbal report of progress of the Committee on Sewer Assessments was made by H. P. Eddy.

The informal report of the Nominating Committee was presented by the chairman of the committee, E. M. Blake. There were no other nominations.

Voted that Mr. Blake be instructed to cast one ballot for the officers and committee as nominated, whereupon the following were declared elected for the ensuing year.

Chairman — Frank A. Marston.
Vice-Chairman — Frank B. Sanborn.
Clerk — Arthur D. Weston.

Additional members of the Executive Committee:

Walter S. McKenzie.
Henry T. Stiff.
Henry A. Varney.

The speaker of the evening was then introduced, Mr. George W. Fuller, consulting engineer, of New York, who gave an interesting discussion on the question, "What Shall Be the Limitation in the Pollution of Raw Waters so that They May Be Safely Purified by Modern Water Treatment Plants?"

The subject was further discussed by Messrs. H. P. Eddy, Robert Spurr Weston and Stephen DeM. Gage.

Voted to extend to Mr. Fuller the appreciation of the Section for his interesting talk.

There were 45 present. Meeting adjourned about 9.30 o'clock.

FRANK A. MARSTON, *Clerk.*

ANNUAL REPORTS.

REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1916-1917.

BOSTON, MASS., March 21, 1917.

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the Constitution, the Board of Government presents its report for the year ending March 21, 1917.

The total membership of the Society a year ago was 999, of whom 875 were members, 83 juniors, 6 honorary members, 26 associates and 9 were members of the Sanitary Section only.

The total loss in membership during the year has been 70, of whom 23 resigned, 31 forfeited membership on account of non-payment of dues, and 16 have died.

There has been added to the Society during the year a total of 37 members of all grades; 36 have been elected and completed their membership, 1 has been reinstated, 6 juniors have been transferred to the grade of member.

Five applicants have been elected but have not completed their membership, and there are 9 applicants now before the Board for action.

The present membership of the Society consists of 5 honorary members, 846 members, 77 juniors, 30 associates and 8 members of the Sanitary Section only, making a total membership of 966.

The loss by death during the year is 16. The record is as follows:

William Thomas Shaw, died February 26, 1916.
 Edward Davis Bolton, died March 10, 1916.
 Erasmus Darwin Leavitt, honorary member, died March 11, 1916.
 Charles Wilson Ross, died April 11, 1916.
 Elmer Lawrence Corthell, died May 16, 1916.
 Frank Edson Shedd, died September 22, 1916.
 John Waldo Ellis, died October 30, 1916.
 William Cooper Cuntz, died November 2, 1916.
 William J. C. Semple, died November 16, 1916.
 William Henry Jaques, died November 23, 1916.
 Harold Parker, died November 29, 1916.
 Edmund Brownell Weston, died December 9, 1916.
 Walter Nathan Charles, died January 20, 1917.
 Alfred Wright Parker, died February 24, 1917.
 Harry C. Foster, died March 5, 1917.
 Willard Wendell Wight, died March 10, 1917.

Under authority of By-Law 8, the Board of Government, for reasons which it deems sufficient, has remitted the dues of ten members of the Society.

Twelve meetings have been held during the year, ten regular and two special. The average attendance at the regular and special meetings was 128+, the largest being 375 and the smallest 13. (The special meeting at which the attendance was so small was held in the Society's Library, and was devoted to a discussion of the metric system of weights and measures.)

The following papers and addresses have been given:

March 15, 1916. — Address of Retiring President Charles R. Gow. Lecture by Dr. Charles H. Tyndale, "The Wonders of Ether Waves and Radium Mysteries." (Illustrated.)

April 21, 1916. — Address by Dr. Alexander C. Humphreys, president Stevens Institute of Technology, "Reform and Regulation."

April 27, 1916. — (Special.) Discussion, "Practical Steps Remaining to be Taken in Completing the Abandonment of Ancient, Customary Units by the Substitution of the Metric System of Weights and Measures."

May 17, 1916. — Mr. Thomas C. Atwood, "The Construction of the Yale Bowl." (Illustrated.)

June 21, 1916. — Address by Rear-Admiral Robert E. Peary, on "National Preparedness."

September 20, 1916. — Mr. Eugene E. Pettee, "The Construction of the Portland Bridge." (Illustrated.)

October 18, 1916. — Mr. H. Whittemore Brown, "The Groined Arch as a Means of Concrete Floor Construction." (Illustrated.)

November 17, 1916. — Mr. Nathan C. Grover, "Effect of Channel on Stream Flow." (Illustrated.)

December 20, 1916. — Mr. Arthur E. Morgan, president of the Morgan Engineering Company, "Flood Control in Miami Valley." (Illustrated.)

January 10, 1917. — (Special.) Mr. Jacob Lowenstein, of the American

Bridge Company, "The Construction and Erection of Hell Gate Bridge." (Illustrated.)

January 24, 1917. — Past-President Desmond FitzGerald, illustrated talk on his travels.

February 21, 1917. — Past-President James W. Rollins, "The New Boston Dry Dock." (Illustrated.)

The Sanitary Section has held nine meetings with an average attendance of 51. The following papers have been presented at the meetings of the Section:

March 1, 1916. — "Eight Months' Experience in Servia with the American Sanitary Commission," by Stanley H. Osborn, M.D., state district health officer for the Berkshire District, Mass.

April 5, 1916. — Preliminary report of committee and discussion of "Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water."

May 3, 1916. — "Sanitary and Hydraulic Work in the Hawaiian Islands," by Arthur R. Keller, professor of civil engineering in the Hawaiian College.

June 7, 1916. — "The Sewage Disposal Problem Confronting the City of Philadelphia," by W. L. Stevenson, assistant engineer in charge, Sewage Disposal, Philadelphia.

November 1, 1916. — Discussion on "Catch Basin Construction and Maintenance," opened by George A. Carpenter.

December 6, 1916. — "How Texas is Protecting the Public Health," by Charles Saville, director of the public health of the city of Dallas, Texas.

December 27, 1916. — "The Agua Clara Filtration Plant at Gatun, C. Z.," by Theodore R. Kendall.

January 3, 1917. — "Outfall Sewer and Pumping Station, Manchester, Mass.," by Raymond C. Allen; "Extension of the Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor," by Clarence A. Moore, assistant engineer, Metropolitan Water and Sewerage Board.

February 7, 1917. — "Sewage Disposal in Rhode Island," by Stephen DeM. Gage.

The joint Engineering Dinner was held at the Boston City Club, on February 7, 1917, under the direction of a committee representing this Society, the local section of the American Society of Mechanical Engineers and that of the American Institute of Electrical Engineers, the latter society taking the more active part in the management this year. The attendance was 451.

The Board of Government has adopted the recommendation of the Committee appointed to award the Desmond FitzGerald medal, and announces that it will be presented this year to Dana M. Wood, for the paper entitled, "Power Estimates from Stream Flow and Rainfall Data," which was published in the JOURNAL of the Society for March, 1916.

The report of the Editor of the JOURNAL for the calendar year 1916, which is submitted for publication with the reports of the other officers of the Society, shows that a total of 859 pages were printed in the ten issues, with 86 cuts and 21 insert plates, at a gross cost of \$3 508.24. The net cost after deducting sum received for advertisements, sales of JOURNALS, etc., was \$1 883.81. The increase in net cost over 1915 is due to the larger number of pages and of illustrations and a very considerable increase in the cost of paper.

Owing to the desire of our tenants for increased space, a lease was taken of the southerly room, adjoining the room of the Hersey Manufacturing Company, at an annual expense of \$450. The Hersey Manufacturing Company and the New England Water Works Association pay \$300 of this amount. Our Society, with this additional expense of \$150, has the advantage of the entire occupancy of the front room, and much needed additional space for library accommodations.

The Legislative Committee which was first appointed by the Board of Government two years ago was continued, and has shown its usefulness in the work during the past year. The committee has kept informed of various legislative bills that appeared to be of special interest to engineers in connection with municipalities, public welfare, conservation, etc., and a general notice was usually given to members whom it was considered might be specially interested, with the result of representation of members at the hearing.

At the February, 1917, meeting, the Society, by vote, tendered its services to the Committee on Public Safety appointed by the Governor of the Commonwealth, to study out and report on the various phases of the preparedness movement.

A committee of the Society has also been appointed to collect, compile and analyze, and to report upon the best figures of run-off in New England which are available for water-power purposes. This committee has begun its work, and it is expected that much valuable data will be gathered.

There has been added to the Permanent Fund during the year \$2 412.48. The present value of the fund is now \$39 888.17, and with the E. K. Turner Fund makes the total amount of the permanent funds of the Society \$40 886.04, an increase during the year of \$2 410.35.

From the Treasurer's report it appears that the revenue for the year applicable to current expenses has been \$9 979.61, an excess of expenditures over receipts of \$621.50. The present cash balance on hand in the current fund is \$573.33.

The Committee on Social Activities, under the direction of its new chairman, Mr. Henry A. Symonds, has continued the practice of arranging an informal dinner to immediately precede the regular meeting of the Society, and, while the attendance has not been as large as in some years, it has been sufficient to show that there is a desire among a number of the members for a gathering of this nature. The report of this committee gives in detail the entertainments which have been provided.

At the January meeting of the Board, the Editor of the JOURNAL, Mr. Edward C. Sherman, tendered his resignation of that position because of removal from Boston. The Board regrets that it was obliged to accept this resignation, as it feels that the success which has attended the publication of our JOURNAL during the three years of its existence is largely due to his efficient services. The position has been filled by the election of Mr. William L. Butcher.

For the Board of Government,

RICHARD A. HALE, *President.*

REPORT OF THE TREASURER.

BOSTON, March 1, 1917.

To the Boston Society of Civil Engineers:

Your Treasurer presents the following report for the year 1916-17:

Detailed data are contained in the appended tabular statements. Table 1 gives the receipts and expenditures for the year; Table 2, comparative balance sheets; and Table 3, investment of the permanent funds.

The revenue applicable to current expenses has been \$9 358.05, being \$84.72 more than for the preceding year. The current expenses were \$9 979.61. The amount of cash on hand is \$573.33.

There has been a large increase in the expense of publishing the JOURNAL, as may be seen by comparing the figures for the past two years, the amounts being \$2 721.20 and \$3 851.48 respectively.

There has been an increase in the Permanent Fund of \$2 412.48, which is less than for the previous year on account of a decrease in the number of entrance fees.

The Turner Fund has been invested in a thousand dollar five per cent. bond of the American Telephone and Telegraph Company.

Respectfully submitted,

FRANK O. WHITNEY, *Treasurer.*

TABLE I. — RECEIPTS AND EXPENDITURES.

CURRENT FUND.

Receipts.

Balance from March, 1916.....	\$1 194.89
Members' Dues.....	7 726.58
Advertisements.....	1 372.50
Sales of JOURNALS.....	209.12
Library Fines.....	6.66
Waste Paper Sold.....	16.88
Interest on Bank Balances.....	26.31

\$10 552.94*Expenditures.*

JOURNAL.....	\$3 851.48
Printing, Stationery, Postage and Library Supplies.....	1 019.89
Rent (net).....	1 745.41
Light.....	75.90
Salaries (except Editor).....	2 119.00
Reporting.....	70.00
Stereopticon.....	62.32
Books.....	81.70

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Binding.....	\$152.05
Periodicals.....	60.45
Incidentals and Repairs.....	354.15
Insurance.....	35.44
Telephone (net).....	20.70
Annual Meeting and Dinner.....	162.40
Committee on Social Activities.....	85.58
Joint Engineers' Dinner.....	15.70
Sanitary Section, Printing, Postage and Stationery.....	25.25
Sanitary Section, Stereopticon.....	30.00
Sanitary Section, Incidentals.....	12.19
Cash on hand.....	573.33
	\$10 552.94

PERMANENT FUND.

Receipts.

Cash on hand, March, 1916.....	\$968.48
Entrance Fees.....	330.00
Contribution.....	100.00
Coöperative Banks, Matured Shares.....	1 007.65
Interest.....	1 691.54
	\$4 097.67

Paid Out.

Coöperative Bank Dues.....	\$900.00
Coöperative Banks, Shares Purchased.....	372.90
Vermont Power & Mfg. Co., Bond Purchased.....	965.00
American Tel. & Tel. Co., Bond Purchased.....	993.75
Cash on hand, March 1, 1917.....	866.02
	\$4 097.67

E. K. TURNER LIBRARY FUND.

Cash on hand, March 1, 1916.....	\$1 000.00
Suffolk Bank, Interest.....	8.75
	\$1 008.75
Vermont Power & Mfg. Co., Bond Purchased.....	\$993.75
Accrued Interest on Bond Paid.....	2.78
Books Purchased.....	8.10
Cash on hand, March 1, 1916.....	4.12
	\$1 008.75

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets.

	March 18, 1914.	March 17, 1915.	March 1, 1916.	March 1, 1917.
Cash.....	\$119.41	\$1 267.73	\$3 163.37	\$1 443.47
Bonds and Notes.....	27 605.50	29 191.75	30 366.25	33 318.75
Stock.....	1 950.00	1 950.00	1 950.00	1 950.00
Coöperative Banks.....	3 545.72	3 212.65	4 190.96	4 747.15
Accounts Receivable (Rents).....	145.83	145.83		
Library.....	7 500.00	7 500.00	7 500.00	7 500.00
Furniture.....	1 325.15	1 950.49	2 405.11	2 405.11
	<u>\$42 191.61</u>	<u>\$45 218.45</u>	<u>\$49 575.69</u>	<u>\$51 364.48</u>

Liabilities:

Permanent Fund.....	\$31 864.29	\$34 582.13	\$37 475.69	\$39 888.17
E. K. Turner Fund.....			1 000.00	997.87
Unexpended Appropriations..	851.46	613.52		
Current Funds.....	535.71	451.31	1 194.89	573.33
Accounts Payable.....	115.00	121.00		
Surplus.....	8 825.15	9 450.49	9 905.11	9 905.11
	<u>\$42 191.61</u>	<u>\$45 218.45</u>	<u>\$49 575.69</u>	<u>\$51 364.48</u>

TABLE 3. — INVESTMENT OF THE PERMANENT FUND, MARCH 1, 1917.

Bonds.

	Par Value.	Actual Cost.	Present Market Value.	Value as Carried on Books.
American Tel. & Tel. Co. col. tr. 4%, 1929.....	\$3 000.00	\$2 328.75	\$2 760.00	\$2 737.50
Union Elec. Light & Power Co. 5%, 1932.....	2 000.00	2 050.00	1 960.00	2 050.00
Blackstone Valley Gas & Elec. Co. 5%, 1939.....	2 000.00	1 995.00	2 000.00	1 995.00
Dayton Gas Co. 5%, 1930.	2 000.00	2 000.00	1 960.00	2 000.00
Milford & Uxbridge St. Ry. 5%, 1918.....	3 000.00	2 942.50	2 970.00	2 942.50
Railway & Light Securities Co. 5%, 1939.....	3 000.00	3 000.00	2 910.00	3 000.00
Superior Light & Power Co. 4%, 1931.....	4 000.00	3 347.50	3 440.00	3 347.50
Wheeling Electric Co. 5%, 1941.....	4 000.00	3 845.00	3 800.00	3 845.00
Economy Light & Power Co. 5%, 1956.....	1 000.00	990.00	990.00	990.00
Tampa Electric Co. 5%, 1933.....	2 000.00	2 000.00	1 980.00	2 000.00

PROCEEDINGS.

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	Par Value.	Actual Cost.	Present Market Value.	Value as Carried on Books.
Galveston Houston Elec. Ry. Co. 5%, 1954.....	\$2 000.00	\$1 940.00	\$1 860.00	\$1 940.00
Northern Texas Elec. Co. 5%, 1940.....	2 000.00	1 932.50	1 860.00	1 932.50
Chicago & Northwestern Ry. 5%, 1987.....	1 000.00	1 102.50	1 160.00	1 102.50
Vermont Power & Mfg. Co. 5%, 1928.....	1 000.00	965.00	940.00	965.00
Am. Tel. & Tel. Co. 5%, 1946.....	1 000.00	993.75	1 010.00	993.75
	<u>\$33 000.00</u>	<u>\$31 432.50</u>	<u>\$31 600.00</u>	<u>\$31 841.25</u>

Note.

Dallas Elec. Co. 5%, 1917.	500.00	483.75	490.00	483.75
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Stock.

15 shares Am. Tel. & Tel. Co.	1 500.00	1 950.00	1 875.00	1 950.00
Total Securities.....	<u>\$35 000.00</u>	<u>\$33 866.25</u>	<u>\$33 965.00</u>	<u>\$34 275.00</u>

Coöperative Banks.

25 shares Merchants Coöperative Bank, including interest to March.....				\$1 495.85
25 shares Volunteer Coöperative Bank, including interest to January.....				1 764.50
25 shares Watertown Coöperative Bank, including interest to March.....				1 486.80
				<u>\$4 747.15</u>

Total value of Invested Funds..... \$39 022.15

Cash on hand..... 866.02

Total value of Permanent Fund..... \$39 888.17

	Par Value.	Actual Cost.	Present Market Value.	
E. K. Turner Fund.				
Am. Tel. & Tel. Co.				
5%, 1946.....	\$1 000.00	\$993.75	\$1 010.00	\$993.75
Cash on hand.....				4.12
				<u>997.87</u>
				<u>\$40 886.04</u>

We have examined the above report and found it correct.

ARTHUR W. DEAN,
GEORGE C. WHIPPLE,
*Auditing Committee of Directors of the
Boston Society of Civil Engineers.*

MARCH 15, 1917.

BOSTON SOCIETY OF CIVIL ENGINEERS.

REPORT OF THE SECRETARY, 1916-17.

BOSTON, MASS., March 21, 1917.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS. *Dr.*

For cash received during the year ending March 21, 1917, as follows:

From entrance fees, new members and transfers:

24 members and associates.....	at \$10 =	\$240.00
12 juniors.....	at 5 =	60.00
6 juniors transferred to members.....	at 5 =	30.00

Total from entrance fees..... \$330.00

From annual dues for 1916-17, including dues from new

members..... \$7 625.08

From back dues..... 22.00

From dues for 1917-18..... 79.50

Total from dues..... 7 726.58

From rents..... 1 089.59

From advertisements..... 1 372.50

From sale of JOURNALS, reprints and cuts 209.12

From sale of old paper..... 16.88

From library fines..... 6.66

From contribution to building fund..... 100.00

Total..... \$10 851.33

The above amount has been paid to the Treasurer, whose receipts the Secretary holds.

We have examined the above report and found it correct.

GEORGE C. WHIPPLE,

ARTHUR W. DEAN,

*Auditing Committee of Directors of the
Boston Society of Civil Engineers.*

REPORT OF LIBRARY COMMITTEE, 1916-17.

BOSTON, MASS., March 21, 1917.

To the Boston Society of Civil Engineers:

The Library Committee submits the following report for the year 1916-17:

Since the last report 475 volumes bound in cloth and 532 bound in paper have been added to the library, making a total of 1 007 accessions.

There are now 9 177 cloth-bound volumes in the library, including such

duplicates from the Edmund K. Turner bequest as have not been disposed of, and the volumes bound in paper number about 2 700.

During the year 386 books have been loaned to members, and fines to the amount of \$6.66 have been collected. It would seem, therefore, that reducing the time during which a book may be kept out, from five weeks to two, has not resulted in a greater number of books being kept out over time, and it has certainly afforded to a greater number of our members an opportunity to use the books, which seems to your committee a fairer arrangement all around, and especially in the case of those books which are most in demand.

The usual amount of binding has been done, and to the list of periodicals to be bound regularly have been added *Good Roads*, *The American City*, *Power*, the *Bulletin* of the General Contractors Association and the *American Journal of Public Health*. For our subscription to the last mentioned of these we are indebted to Mr. Harrison P. Eddy.

Of the sixteen new engineering books added to Section 10, one, "The American Road," was presented to the library by its author, Prof. James I. Tucker, of the University of Oklahoma, and the remaining fifteen were purchased. Of these fifteen, two, on railroad engineering, were purchased from the income of the Turner Fund. The choice of subject was suggested by Mr. Turner's well-known interest in railroad engineering.

A revolving bookcase, the gift of Mr. Frank A. Barbour, has been added to the furnishings of the library. A sectional oak cabinet has also been installed in the reading-room by the Catalogue Equipment and Supply Company, and contains its collection of trade catalogues known as "Catalogue Studies," described in the December, 1916, issue of the JOURNAL.

During the year there have been received from members several miscellaneous donations of reports, periodicals, etc. Donations of this sort and the interest which prompts them are greatly appreciated. While they contain a great many duplicates which must be sorted out and disposed of, there often remain, after these have been weeded out, a considerable number of copies needed for the completion of the Society's files.

The increasing number of duplicates which seemed too valuable to throw away has led to the establishment of a practice which seems to be appreciated by our members. Beginning with September, 1916, a list of duplicates for free distribution to members has appeared each month in the Society's JOURNAL. The committee is pleased to note that the greater part of these duplicates have proved acceptable to the members, and the practice will be continued. It will not be possible, of course, to publish a list every month, but a list will appear as often as the number and character of the duplicates on hand warrant it.

The work of completing files of reports and magazines, indexing, re-arranging, etc., is being continued with good results, though it has been more or less impeded by lack of space, the extra shelf and storage room afforded by the enlargement of the Society's quarters not having been available until this week. The remainder of Section 1, Society Publications, and the whole of

Section 2, Periodicals, have been catalogued, and*to the card index of papers read before the Society have been added author, subject and, in cases where it seemed advisable, title cards for all papers read before the Sanitary Section.

Respectfully submitted,

S. E. TINKHAM,
FREDERIC I. WINSLOW,
HENRY F. BRYANT,

Committee on Library.

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 7, 1917.

To the Sanitary Section, Boston Society of Civil Engineers:

The program for the past year has included nine meetings, the subjects and speakers being as follows:

March 1, 1916. — "Eight Months' Experiences in Servia with the American Sanitary Commission," by Stanley H. Osborn, M.D., state district health officer for the Berkshire District, Mass.

April 5, 1916. — Preliminary report of committee and discussion of "Methods of Design and Construction and Results of Operation of Inverted Siphons for Carrying Sewage Only and for Storm Water."

May 3, 1916. — "Sanitary and Hydraulic Work in the Hawaiian Islands," by Arthur R. Keller, professor of civil engineering in the Hawaiian College.

June 7, 1916. — "The Sewage Disposal Problem Confronting the City of Philadelphia," by W. L. Stevenson, assistant engineer in charge, Sewage Disposal, Philadelphia.

November 1, 1916. — Discussion on "Catch Basin Construction and Maintenance," opened by George A. Carpenter.

December 6, 1916. — "How Texas is Protecting the Public Health," by Charles Saville, director of public health of the city of Dallas, Tex.

December 27, 1916. — "The Agua Clara Filtration Plant at Gatun, C. Z.," by Theodore R. Kendall.

January 3, 1917. — "Outfall Sewer and Pumping Station, Manchester, Mass.," by Raymond C. Allen; "Extension of the Metropolitan Sewerage System Outfall at Deer Island, Boston Harbor," by Clarence A. Moore, assistant engineer, Metropolitan Water and Sewerage Board.

February 7, 1917. — "Sewage Disposal in Rhode Island," by Stephen DeM. Gage.

It is interesting to note that five of the list of speakers are from outside the membership of the Society. Lantern slides were used at all except one meeting. Much of the material has been published in the JOURNAL, and there still remains the report of the Committee on Inverted Siphons, which it is hoped will be available for publishing soon.

One meeting was held at the Engineers' Club, six in the Society Library, and two in Chipman Hall. The records seem to indicate that there is but little to be gained by holding the meetings in Chipman Hall, and that, if some method of mechanical ventilation could be installed in the Library, that room would be preferable as a meeting place for the Sanitary Section. The expense

would be somewhat less. If the meetings are held regularly in the Library, a more satisfactory screen could be installed, in order that satisfactory results may be obtained in using the lantern.

The Executive Committee deemed it best to omit dinners in connection with the meetings, largely because of the increased cost.

March 1, 1916 (annual meeting).....	65
April 5, 1916.....	54
May 3, 1916.....	37
June 7, 1916.....	46
November 1, 1916.....	60
December 6, 1916.....	61
December 27, 1916.....	29
January 3, 1917.....	64
February 7, 1917.....	42
Average.....	51

The total membership of the Section is 184, of whom 1 is an honorary member, 8 are members of the Sanitary Section only, 8 are juniors and 1 an associate.

During the past year the Section has authorized the appointment of one special committee,—that on the distribution of excessive rainfall in Boston and vicinity. There are three other special committees in service.

It is recommended: That the Board of Government of the Society be requested to consider the advisability of and if possible bring about the installation of mechanical ventilating apparatus in the Library, in order that the Section meetings may be held in that room with greater comfort. Also, that a more satisfactory screen be installed for use with the lantern.

Respectfully submitted for the Executive Committee,

FRANK A. MARSTON, *Clerk.*

REPORT OF THE COMMITTEE ON SOCIAL ACTIVITIES.

BOSTON, MASS., March 21, 1917.

To the Boston Society of Civil Engineers:

The Committee on Social Activities presents the following brief outline of the work during the past year:

The committee has participated in the preparation for entertainments; for the joint outing with the New England Water Works Association held last June, at Pemberton; four dinners at the City Club, and the Ladies' Night.

The attendance at the June meeting was very satisfactory, and we believe the outing to have been a thorough success, and recommend its continuance.

The talk by Rear-Admiral Peary was greatly enjoyed by the members and guests.

We regret to state that the ball game was won by the New England Water Works Association team.

An informal dinner at the City Club was held on October 17, with an attendance of 29. The entertainment was furnished by Wendell Mason, a reader and entertainer of large reputation. The toastmaster on this occasion was Edmund M. Blake — no further comments necessary.

The second informal dinner at the City Club was held on November 15, with an attendance of 63. We were then given a remarkable word picture of the British campaign at Gallipoli by John Gallishaw, a Harvard senior. Past President Gow did the honors and threw in some of his good stories.

The third informal dinner at the City Club was held December 20, with an attendance of 27. Through the efforts of Dean Burton, of the Massachusetts Institute of Technology, the M. I. T. vocal quartet and a quartet from the Banjo Club accepted an invitation to the dinner, and gave a delightful entertainment. Edward C. Sherman acted as toastmaster, and greatly helped the entertainment along by his good stories and timely hits. Messrs. Blake and Eddy told some good stories, and Mr. Arthur E. Morgan, the speaker at the regular meeting of the Society, gave an interesting informal talk.

Ladies' Night was held in Chipman Hall, January 24, with an attendance of 88. It is almost superfluous to add to the expressions of gratitude to Mr. Desmond FitzGerald for his kindness in presenting a section of his wonderful travel pictures, as one more of the innumerable acts by Mr. FitzGerald in the interests of the Society and for the pleasures of its members. Music was furnished for the evening by an amateur orchestra from the Newton High School, led by Allen Symonds.

The last informal dinner of the Society year was held on February 21, with an attendance of 54, David A. Ambrose very ably presiding. Samuel J. Simmons, a veteran of the Civil War, who passed through some of the hottest engagements of that conflict, vividly described some of his experiences.

The chairman wishes to express his appreciation of the assistance given by the other members of the Committee on Social Activities, who have always held themselves ready to take a hand, and give their best efforts towards making the meetings a success.

It is perhaps proper at this time for the chairman of this committee to mention briefly one or two points with which the present committee have had to deal, and with which future committees must contend.

It is generally understood to be the principal function of the Committee on Social Activities to provide such features as will promote the interests of the regular meetings, enlarge the attendance, and increase the enjoyment of all who attend.

The general plan, originated by the first Committee on Social Activities, seemed to work very successfully in the past in arousing interest in the Society, and in bringing out a good attendance.

It is true that in many cases the attendance at the dinner exceeded that at the regular meetings, and it was found that only a fraction of those attending the dinners stayed for the regular meetings. In this respect the exact purpose was not carried out, but we believe a great good was accomplished by the social intercourse brought about through these dinners.

We must acknowledge the falling off in attendance at the dinners during the last year, and, to face the causes frankly, we believe it due to three reasons.

It would be dodging the issue not to admit the wonderful ability and power of Chairman Blake of the past committees to arouse enthusiasm and interest in these dinners. More missionary work was done during the former years than has been practicable by the present committee, in efforts to bring out large attendance.

The increased cost of everything has compelled the City Club to advance its prices for dinners of this class.

Another important cause is probably the fact that the informal dinners are getting to be somewhat of an old story.

Fully realizing the handicap of these conditions, the Committee on Social Activities has canvassed the field in an effort to provide a different form of entertainment to break up the monotony, and to obtain better rates, but have been unable to strike a combination which seemed to fill the needs of the Society as well as the informal dinners at the City Club.

In the interests of the next committee, and in fact in the interests of all committees who have to arrange for dinners of one kind or another for the Society, the chairman of this committee wishes to urge upon your attention the importance of giving prompt notice by postal card of intention to attend the dinners. This is not intended in the slightest degree to include those who are unable to tell until the night of the meeting whether they can attend or not, or who have to change their minds at the last minute, but it is aimed at those who carelessly neglect to give notice when they fully intend to attend. The failure of a large number to state their intentions is a source of some anxiety and embarrassment to the committees, as the clubs or caterers who furnish dinners of this kind usually require an estimate of what the attendance will be, ahead of the meeting.

If your committee of 1916-1917 has succeeded in promoting better fellowship and acquaintance among the members of the Boston Society of Civil Engineers; has added attractiveness to the meetings; interested those not previously members, who at first attend as guests at the dinners and afterwards join the Society; has added in any degree to the success of the regular meetings, to that extent we have accomplished the purpose of our existence.

Very respectfully submitted,

HENRY A. SYMONDS,

Chairman Committee on Social Activities.

JANUARY 24, 1917.

TO THE BOARD OF GOVERNMENT OF THE BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen, — I have the honor to submit the following report on the JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS for the year 1916.

The usual ten numbers of the JOURNAL were issued, 1 250 copies of each

being printed. This number provides a few spare copies of each issue, but is not too large.

There were published, in 1916, 26 papers, 6 discussions and 9 memoirs of deceased members. Including the proceedings, papers, discussions, index and advertising, a total of 859 pages were printed. Eighty-six cuts and 21 inserted plates were used with the papers published, and the gross cost of the whole was \$3 508.24. Receipts from subscriptions, sales of JOURNALS and advertisements made the net cost \$1 883.81.

The increase in net cost over 1915 is due to the larger number of pages printed, to the use of more illustrations and to the very considerable increase in the cost of paper.

The details of the number of pages printed and the costs are given in the accompanying table.

Respectfully submitted,

(Signed) EDWARD C. SHERMAN, *Editor*.

APPLICATIONS FOR MEMBERSHIP.

[April 4, 1917.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

COOMBS, ANTHONY S., Allston, Mass. (Age 26, b. Chelsea, Mass.) Graduate of Mechanic Arts High School, 1908; continued education in post-graduate course (1909), I. C. S. course in civil engineering, course in reinforced concrete, Albany Evening High School, and special course in rein-

PROCEEDINGS.

23*

Month.	PAGES OF				No. of		COST OF							
	Papers.	Proc.	Index.	Adv.	In-sets.	Cuts.	Papers, Proc. and Index.	Cuts.	Adv'ts.	Reprints.	Postage, Wrapping and Mailing.	Editing.	Incident-als.	Copyright and Tax.
Jan.	42	14		17		7	\$147.55	\$16.20	\$19.01	\$10.50	\$20.42		\$3.55	
Feb.	33	12		17		2	130.35	3.80	19.50	4.08	16.96		.37	
Mar.	48	18		17		8	181.53	11.10	18.03	15.00	22.35		.85	
Apr.	54	36		17	6	10	328.43	22.05	22.16	25.50	20.01		1.24	
May	52	11		17	2	3	195.74	7.45	16.81	17.00	29.93		3.32	
June	100	14		16½		13	312.30	8.34	15.81	24.83	20.57		.40	
Sept.	108	18		16½	2	12	370.45	29.96	18.00	19.51	25.63		1.66	
Oct.	26	11		16½	1	7	147.00	22.35	20.25	15.36	20.33		1.00	
Nov.	21	13		16½		6	121.63	6.75	18.65	8.77	20.73		.76	
Dec.	24	14	10	16½	10	18	283.26	116.16	24.70	12.50	25.63		3.26	
Total	508	161	10	167¼*	21	86	\$2,218.24	\$244.16	\$192.92	\$153.05	\$222.56	\$450.00	\$16.41	\$11.00

Total number of pages, 859.

Total gross cost..... \$3,508.34
 Subscriptions..... \$64.40
 Sales of JOURNALS..... 86.13
 Advertisements..... 1 474.00

Total net cost..... 1 624.53
 \$1 883.81

* 18 pp. used each month; not set solid.

forced concrete at Harvard University, January to March, 1915; has passed New York State civil service examinations for tracer, chainman, rodman, leveler and assistant engineer; member of Technology Club of Syracuse during stay in that city. Timekeeper and stock clerk for Pittsburg-Eastern Co., from May, 1909, to January, 1910, and for Acme Engineering and Contracting Co. on New York Barge Canal work from January to April, 1910; from April, 1910, to August, 1911, with New York State Highway Dept. on plans, construction, etc.; from August, 1911, to January, 1915, with Alto Construction Co. of Utica, N. Y., on cost analysis work, etc.; from March to September, 1915, inspector with Carley Life Float Co., Cambridge, Mass.; from September, 1915, to date, field engineer and draftsman on building construction with Whidden-Beekman Co., Boston. Refers to L. J. Johnson and G. C. Whipple.

EATON, ARTHUR C., Worcester, Mass. (Age 33, b. Lunenburg, Mass.) Graduate of Civil Engineering Department, University of Vermont, 1907. In 1905, timekeeper for three months on Massachusetts highway construction; in 1906, rodman for three months on Catskill Aqueduct surveys; in 1907, rodman for five months with New York State Highway Dept.; during year 1907-08, instructor in civil engineering, University of Vermont; from 1908 to 1909, leveler with New York State Water Supply Comm.; for six weeks in 1909, with U. S. Geological Survey, Hydrographic Branch; from 1910 to 1911, leveler on New York State Barge Canal; from 1911 to 1912, assistant engineer with Barrows & Breed, Boston; from May, 1912, to date, assistant hydraulic engineer with Power Construction Co. of Worcester. Refers to H. K. Barrows, R. A. Hale, C. H. Pierce and A. T. Safford.

PHILLIPS, LAURENCE JOSLYN, Cambridge, Mass. (Age 20, b. Cambridge, Mass.) Student for two years at Rindge Manual Training School, Cambridge; is now completing second year of structural engineering course at Northeastern College, Boston Y. M. C. A. From August, 1911, to date, draftsman, timekeeper, etc., with Whidden-Beekman Co.; is now in charge of estimating department and of certain parts of construction work. Refers to C. S. Ell and Robert Rand.

LIST OF MEMBERS.

ADDITIONS.

BARRY, CHARLES G..... Sandwich, Mass.
BRESTH, ALEXANDER..... 119 Pembroke St., Boston, Mass.
CROCKER, HAROLD S..... City Hall, Brockton, Mass.
PIKE, WALDO F..... 67 Dana St., Cambridge, Mass.

CHANGES OF ADDRESS.

ALBEE, EDWARD E..... 11 Orris St., Melrose Highlands, Mass.
ALDEN, HOWARD K..... 8 Ellsworth Ave., Cambridge, Mass.
AIKEN, ROY C..... City Water Dept., Waltham, Mass.
APPLETON, ARTHUR B..... 15 Dane St., Beverly, Mass.

- BARNES, ROWLAND H.....88 Broad St., Boston, Mass.
 BARKER, JOHN K.....33 Lyman St., Springfield, Mass.
 BARRETT, ROBERT E.....308 Boylston St., Boston, Mass.
 BATEMAN, LUTHER H.....Room 472, State House, Boston, Mass.
 BRADBURY, ROYALL D....Clinton Wire Cloth Co., Sears Bldg., Boston, Mass.
 BREEN, CHARLES H.....Beacon Chambers, Boston, Mass.
 BRUNEL, RICHARD.....Moulton Engineering Corp., Portland, Me.
 CARTER, CLARENCE E.....9 Masonic Block, Reading, Mass.
 CLARK, CHARLES S.....Room 919, 141 Milk St., Boston, Mass.
 COBURN, FRANK R., Valuation Dept., Grand Trunk Ry., Montreal, Canada
 COBURN, WILLIAM H., care of Marshall & Co., Inc., 70 State St., Boston, Mass.
 COFFIN, S. P.....Allston, Mass.
 COGHLAN, JOHN H.....53 Wollaston Ave., Arlington, Mass.
 DOLLIVER, HENRY F.....23 East Main St., Webster, Mass.
 DURFEE, WALTER C.....8 Parley Vale, Jamaica Plain, Mass.
 EBERHARD, WALTER C.....60 Church St., Rutland, Vt.
 FARRELL, FRANCIS B.....158 Walnut St., Springfield, Mass.
 FOOTE, FRANCIS C.....2541 Oliver Bldg., Pittsburgh, Pa.
 HATHAWAY, ERWIN O.,
 U. S. Office Public Roads, P. O. Bldg., Minneapolis, Minn.
 HODGES, GILBERT.....Main Street Station, Franklin, N. H.
 HOLMES, ALBERT J.....Hotel Belvedere, Bristol, R. I.
 HOSMER, GEORGE L.....280 Washington St., Woburn, Mass.
 HOXIE, ARTHUR E.....Laconia, N. H.
 HOYT, LAWRENCE B.....15 Orient Place, Melrose, Mass.
 HUGHES, HECTOR J.....M. I. T., 1-337, Cambridge, Mass.
 HUNTER, WILLIAM B.....20 Rollins Place, Yonkers, N. Y.
 HURLEY, HERBERT D., Commission on Waterways and Public Lands,
 Dry Dock Office, South Boston, Mass.
 JOHNSON, LEWIS J.....M. I. T., 1-280, Cambridge, Mass.
 KENDALL, THEODORE R.,
 Engrg. Editor, *American City*, 154 Nassau St., New York, N. Y.
 KIMBALL, ERNEST R.....336 Mystic St., Arlington, Mass.
 KITFIELD, EDWARD H.....85 Water St., Boston, Mass.
 KLINK, NASSIME S.....25 Cowing St., West Roxbury, Mass.
 LAWRENCE, WILLIAM H.....72 Sumner Rd., Dorchester, Mass.
 McCORKINDALE, RALPH.....16 Summit Ave., Lawrence, Mass.
 MULLEN, LUKE D.....Charlestown Trust Co., City Sq., Charlestown, Mass.
 NASH, PHILIP C.....99 Winsor Ave., Watertown, Mass.
 NICHOLS, CHARLES E.....147 Milk St., Boston, Mass.
 O'BRIEN, JOSEPH H.,
 Central Constr. Corp., Commonwealth Trust Co. Bldg., Harrisburg, Pa.
 PITCHER, SAMUEL H.....Room 32, 44 Front St., Worcester, Mass.
 RABLIN, JOHN R.....18 Tremont St., Boston, Mass.
 RICHMOND, CARL G.....26 Hichborn St., Revere, Mass.
 SARGENT, ALBERT F.....1 Salem St., Malden, Mass.

SEAGRAVE, ARNOLD.....	27 Commercial Bldg., Woonsocket, R. I.
SKINNER, FENWICK F.....	Room 1705, 21 Park Row, New York, N. Y.
SMITH, SIDNEY.....	91 Maple St., West Roxbury, Mass.
SMITH, WILLIAM H.....	315 Mt. Vernon St., Dedham, Mass.
SNOW, LESLIE W.....	8 Story St., Cambridge, Mass.
SOKOLL, JACOB M.....	20 Garden St., Boston, Mass.
SPEAR, WALTER E.....	Municipal Bldg., 22d Floor, New York, N. Y.
TERHUNE, HOWARD H.....	care of Fred T. Ley Company, Springfield, Mass.
WASON, LEONARD C.....	1530 Beacon St., Brookline, Mass.
WEBB, DEWITT C.....	469 State House, Boston, Mass.
WILLIAMS, WILLIAM F.....	473 State House, Boston, Mass.
WINSLOW, FREDERICK I.....	501 City Hall Annex, Boston, Mass.
WOOD, HENRY B.....	413 State House, Boston, Mass.

DEATHS.

SEMPLE, WILLIAM J. C.....	November 19, 1916.
CLAPP, OTIS F.....	March 3, 1917.
FOSTER, HARRY C.....	March 5, 1917.
WIGHT, WILLARD W.....	March 10, 1917.
DAVIS, JOSEPH P.....	March 31, 1917.

RESIGNATIONS.

(In effect March 21, 1917.)

AMES, BERTRAM E.	HORTON, THEODORE.
BICKFORD, JOHN W.	HOSMER, SIDNEY.
BOLLING, GEORGE E.	KIRKPATRICK, JOHN J.
CURRIER, GEORGE C.	LANGLEY, MILES E.
DEVINE, WALTER A.	NEWTON, JEWETT B.
DOWST, EVERETT F.	PENARD, THOMAS E.
DUTTON, CHARLES H.	PHELAN, JOHN J.
FERRIS, RAYMOND W.	SOPER, GEORGE A.
FOX, SAMUEL M.	SOUTHER, THEODORE W.
GALLENE, VICTOR J.	STRADLING, DAVID W.
GLADDING, RAYMOND D.	STUCKLEN, CARL L.
GREENE, FRANCIS I.	WALES, WINTHROP L.
HARRISON, CHRISTOPHER.	WESTON, CLARENCE M.
HIGGINS, HERMAN K.	

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society rooms two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

399. Age 27. Has had good education in mathematics through trigonometry, and considerable experience in land-surveying with compass. Desires position with civil engineer which would give him opportunity to qualify as transitman.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Anticlines in Blackfeet Indian Reservation, Montana. Eugene Stebinger.

Coals in Area between Bon Air and Clifty, Tennessee. Charles Butts.

Earth, Sand-Clay and Gravel Roads. Charles H. Moorefield.

Farms, Forests, and Erosion. Samuel T. Dana.

Garrison and Philipsburg Phosphate Fields, Montana. J. T. Pardee.

Lumbering in Sugar and Yellow Pine Region of California. Swift Berry.

Nickel in 1915. Frank L. Hess.

Placer Deposits of Manhattan District, Nevada. Henry G. Ferguson.

Public Road Mileage and Revenues in Southern States, 1914.

Theory of Drying and Its Application to New Humidity-regulated and Recirculating Dry Kiln. Harry D. Tiemann.

Water-Supply Papers 392, 402, 419, 420 and 421.

State Reports.

Massachusetts. Annual Report of Homestead Commission for 1916.

Michigan. Report of Tuberculosis Survey of State Board of Health for 1915-16.

Municipal Reports.

Belmont, Mass. Annual Report of Water Commissioners for 1916.

Danvers, Mass. Annual Report of Water Commissioners for 1916.

Detroit, Mich. Annual Report of Water Commissioners for 1915-16.

Dover, N. H. Annual Report of Water Commissioners for 1916.

Reading, Mass. Annual Report of Water Commissioners for 1916.

Rutland, Vt. Annual Report for 1916.

Miscellaneous.

American Institute of Mining Engineers: Transactions for 1916, Vol. LIV.

American Society of Civil Engineers: Transactions, Vol. LXXX, 1916.

Comparison of Activated Sludge and Imhoff Tank-Trickling Filter Processes of Sewage Treatment. Harrison P. Eddy. Gift of author.

Canada, Department of Interior: Report of Hydrometric Surveys for 1915.

Treatise on Concrete Plain and Reinforced. Frederick W. Taylor and Sanford E. Thompson. 3d ed. Gift of S. E. Thompson.

Municipal Engineers of City of New York: Proceedings for 1915.

Practical Plan of Engineering Coöperation. F. H. Newell. Reinforced Concrete Design Tables. M. Edgar Thomas and Charles E. Nichols. Gift of C. E. Nichols.

Sewage Treatment by Aëration and Activation. George T. Hammond. Gift of author.

Spray Engineering Co.: Condensed Summarization of Principal Spraco Developments, 1917.

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 1st of each month.)

City of Boston. — PUBLIC WORKS DEPARTMENT. — HIGHWAY DIVISION, PAVING SERVICE.

Hill Top St.,	Granite Ave. to Hallet St.	Bituminous macadam.
Gaffney St.,	Commonwealth Ave. to B. & A.R.R.	Asphalt.
Caledonian Ave.,	Spring St. 200 feet northerly.	Grading.
Patten St.,	Hyde Park Ave. to Bourne St.	Bituminous macadam.
St. Rose St.,	South St. 416 feet westerly.	Bituminous macadam.
Amory St.,	Centre St. to Bragdon St.	Granite block.

PUBLIC WORKS DEPARTMENT.—BRIDGE AND FERRY DIVISION. — *Strandway Improvement.* — This work involves the extension of the concrete sewer outlets at H, Vale and Kemp streets and Crescent Ave.; the construction of a wooden bulkhead 1 700 ft. long, extending easterly from a point near Columbia Road Bridge into Old Harbor; reclamation of some seventy-five acres of flat land on the shores adjacent to Old Harbor by hydraulic fill; the construction of a fifty-six acre playground, surrounded by suitable drives and walks; and the construction of a new concrete bath-house near McKenzie Beach, capable of bathing four thousand people per day.

On this improvement there has been completed, to date, the construction of 400 ft. of 2 ft. by 3 ft. concrete sewer between H and I streets. The construction of the cofferdams for the Vale, Kemp streets and Crescent Ave. sewers is well under way; as is also the building of the bulkhead. Dredging and filling operations have been started.

Boston Elevated Railway Company, Bureau of Elevated and Subway Construction. — *Mystic River Bridge.* — The channel piers, abutments and intermediate piers, excepting two at the present or old channel, are completed. The steelwork for the bascule draw is substantially completed, and erection will probably begin on or about April 1; the balance of the steel

structure north of the draw is substantially completed, and erection is expected to begin some time during April.

Reconstruction of Malden Bridge.—Active work on the reconstruction of the bridge was begun in March, and the portions immediately adjacent to the new draw are now under construction. The fill north of the draw and on Alford St. as relocated will be started early in the coming month.

New York, New Haven and Hartford Railroad.—CONSTRUCTION DEPARTMENT.—Work consists of new 39-stall engine house, 95-ft. turntable, ash pits, boiler house, office building, water tank and necessary trackage.

During the past month completed following: Excavation for sand drying plant; driving concrete piles for ash pits and water tank and plugs; concrete foundations for engine house and turntable pit.

Progressing on the following: Pouring concrete foundation for office building, ash pits, and sand drying house; erecting brick and terra cotta, wood sash, louvres, timber framing, matched roof, timber rail supports and structural steel of engine house; excavation for water tank and plugs; relocating Western Union pole line; moving railroad company telephone and signal wires; laying temporary track to make fill for permanent tracks.

BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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HISTORY AND PRESENT STATUS OF THE CONCRETE
PILE INDUSTRY.*

BY CHARLES R. GOW, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.†

PRIOR to the beginning of the present century, piling for foundation purposes as used in this country was almost invariably of wood. It is true, of course, that special conditions had at times imposed the necessity of introducing substitutes for wood piling, and the use of iron and screw piles was more or less familiar to engineers of that period. Sand piles had been used in a limited way, and the writer recalls having seen light steel shells filled with concrete and buried in the ground as foundation supports during the late years of the last century.

It was generally recognized, however, that wooden piling although relatively cheap was poorly suited for many of its requirements. The necessity of cutting wooden piles below permanent ground water level frequently required excessive amounts of excavation and correspondingly large masses of masonry to bring the footings to grade. If the ground water level was in any way liable to future depression, there was justification for more or less apprehension as to the future integrity

NOTE. This paper is issued in advance of date set for its presentation. Discussion is invited, to be received by W. L. Butcher, Editor, 14 Beacon Street, Boston, before August 10, 1917, for publication in a subsequent issue of the JOURNAL.

* This paper was presented before the American Concrete Institute, February 9, 1917.

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of the structure which the pile supported. Again, the amount of loading which could be applied safely on wooden piles was comparatively small. The liability of breakage during the process of driving was also recognized by engineers, as was the fact that such breakage could not always be readily detected by means of surface indications.

These and other considerations have called for the exercise of ingenuity on the engineer's part in providing a satisfactory substitute for wooden piles which would eliminate their disadvantageous features. The general adoption of concrete as a building material during the late years of the past century naturally led to its introduction for various structural purposes and it was soon applied as a means to take the place of wooden piling. From that time on, the application of concrete to the piling industry enjoyed a rapid and encouraging growth, and to-day its use throughout the world has assumed very substantial proportions. The experimental stage has long since passed, and we now universally accept the concrete pile in its many forms as an available expedient for the solution of our physical and economic foundation problems.

In the development of the concrete pile industry there have ensued two distinct types or groups, viz., those which are pre-cast on the surface and later driven in substantially the same manner as are wooden piles, and the so-called "built-in-place" piles, which are cast in their final positions after the necessary opening in the soil has been obtained by means of temporary or permanent forms or shells. These two types of piles will be treated separately.

PRE-CAST CONCRETE PILES.

It was natural that the earlier adaptations of concrete to piling should follow in form and methods the previous experience with wooden piles. Accordingly, concrete piles were first cast in molds of approximately the dimensions of heavy wooden piles, or somewhat larger, and in general a rectangular cross-section was adopted for convenience rather than the circular shape. The first piles of this type to be used, so far as there is record, were introduced in France by Hennebique during the

year 1896, and their introduction into the United States followed some years later. Generally speaking, pre-cast piles are built with a square, hexagonal or octagonal cross-section. When the square section is adopted, it is customary to chamfer the corners slightly, in order to avoid the danger of chipping during handling. The piles are usually cast with a diameter of from 12 in. to 24 in., depending upon their length and the load they are to carry.

This type of pile is almost invariably reinforced with some suitable arrangement of longitudinal bars and circumferential hooping. In many instances the hooping consists of a spiral winding either of wire or small-sized round or flat bars. In a number of instances, sheets of electrically welded wire fabric have been utilized as reinforcement in piles of moderate length, the heavier wires of the mesh extending in the longitudinal direction, while the lighter strands serve as transverse hooping. In some instances, additional reinforcement is provided near the top of the pile to resist the tendency for the head to rupture under the impact of the hammer. Similarly, in the case of very long piles, extra longitudinal rods are used to strengthen the middle section against stresses due to preliminary handling. While the method described above is the customary practise in reinforcing these piles, other types of reinforcement may be and have been adopted, as, for instance, angle irons connected by lattice bars or even I-beams incased in concrete, the object being always to insure the necessary strength to withstand the stresses which may be induced in the pile due to handling, driving or loading. In the ordinary case, it usually will be found that the greatest stresses will be developed when the pile is picked up in a horizontal position and supported by means of a single fastening at the middle of its length.

Protection at the point is often afforded by the use of a cast-iron steel point or shoe (Fig. 1), which usually is cast integral with the pile and secured to it by means of adequate anchorage. The function of this special point is, of course, to prevent breakage at the tip of the pile during driving, which might result from encountering bowlders or other obstructions.

In many cases a jet pipe is provided for in casting the pile,

elbow. This arrangement eliminates certain difficulties in operating the jet during the driving process.

Pre-cast piles are sometimes built with a longitudinal taper. Sometimes they are of uniform section throughout, while still others are uniform in section except for a short length near the tip, which is tapered to give a long, wedge-shaped driving point.

In a few instances, piles have been cast with a hollow section when it was desired to obtain a maximum of stiffness with a minimum of weight. These are naturally more expensive to build, and the type is not especially common.

None of the above features is patented, and any of them may be adopted at will. Such patents as have applied to the pre-cast type of pile are usually confined to one or more special features either in the details of design or in the method of making and driving. These features are supposed to afford better results in many respects than ordinarily could be obtained by means of the unpatented types.

Among the special patented types of pre-cast piles in more or less common use at the present time, in this country, may be mentioned the following:

The Chenoweth Pile.

The "Chenoweth" pile, patented in 1904 by Mr. A. C. Chenoweth, of Brooklyn, N. Y., depends chiefly for its patentable features upon the novel method of its manufacture. This and the resulting arrangement of its reinforcing metal give to it special properties which materially assist in facilitating its safe handling and driving. The pile is circular in cross-section, with a variable diameter from 12 in. upward, dependent upon the length of the pile required. This pile is formed in the following manner (Fig. 2):

A slightly inclined table is constructed of a length somewhat in excess of that of the pile to be made. This table is free to move laterally upon suitable rolls. Near the upper edge of the inclined table is secured a length of 2-in. pipe, capable of being revolved. To this pipe is attached one longitudinal edge of a sheet of expanded metal or fine wire mesh, which is spread flat upon the surface of the inclined table. Upon this sheet of metal

fabric, longitudinal reinforcing rods are laid at intervals and wired to the mesh. A layer of moderately stiff concrete is then spread over the prepared reinforcement and shaped by means of a template so as to conform to certain necessary requirements. The 2-in. pipe is now revolved, drawing the table with its contents toward it as the combined layers of steel and concrete are wrapped about it. Simultaneously, a heavy roll immediately above the 2-in. pipe bears against the outer surface of the pile, imparting to it the required cross-section. After the rotation



FIG. 2. CONSTRUCTION OF CHENOWETH PILE.

is completed, the pile is bound at frequent intervals with small wires. It will be seen that the resulting pile section resembles somewhat the arrangement of the layers in a jelly roll, the metal fabric with its attached longitudinal rods forming the spiral hooping which affords great strength against stresses due to handling and driving.

The Corrugated Pile.

The "corrugated" pile (Fig. 3), patented in 1908 by Frank B. Gilbreth, of New York, is octagonal in section, with a uniform

taper from 20 in. to 11 in. It is reinforced with a circular cage of Clinton electrically welded wire fabric. Its patentable features consist chiefly of longitudinal semicircular corrugations in the middle of each of its eight exterior faces and of a tapered cored passage in the center of the pile, which is formed by casting a wooden mandrel in the center of the pile having a 4-in. diameter at one end and a 2-in. diameter at the opposite end. The large end of this wooden mandrel projects sufficiently through the end of the form so that it may be given a slight turn after the concrete is partially set, thus breaking its bond with the concrete and permitting its easy withdrawal when the concrete is thoroughly hardened. The purpose of the corrugations is intended to be twofold. First, to afford a ready passage for the water returning from the jet pipe to the surface, and, second, to increase the total perimeter of the cross-section, thereby making possible a greater frictional contact with the soil. The cored passage in the center of the pile serves as a means for the introduction of the jet pipe and thereby eliminates loss which would ensue through building a separate pipe in the center of each pile. So far as the efficacy of the corrugations is concerned, it may be questioned whether they add in any way to the ease of driving. It would seem that the increased perimeter might better be obtained by the adoption of a square rather than an octagonal section, though it may be argued that an equivalent superficial area is obtained in this manner with a less amount of concrete. This type of pile enjoyed a certain degree of popularity for a time but has been little used of late years, so far as the writer is aware.



FIG. 3.
CORRUGATED
CONCRETE
PILE.

The Cummings Pile.

The "Cummings" pile (Fig. 4), patented by Mr. R. A. Cummings, of Pittsburg, Pa., is distinguished from the unpatented types chiefly by the introduction of a special design of reinforcement in the head of the pile which avoids danger

patentable feature consists of a double jetting system. A 4-in. jet pipe extends longitudinally through the center of the pile, being reduced at the pile point to $1\frac{1}{8}$ in. This 4-in. pipe is tapped at frequent intervals and connected by means of $\frac{3}{4}$ -in. nipples with the four outer faces of the pile. The outer extremities of these nipples are turned upwards by means of right-angle elbows. In addition, a 2-in. jet pipe is inserted inside the 4-in. pipe and connected with the $1\frac{1}{8}$ -in. nozzle at the point. By

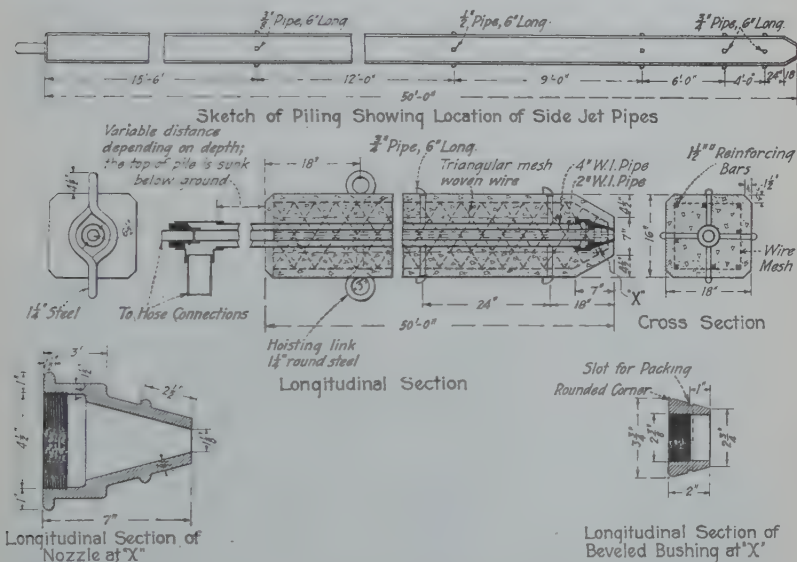
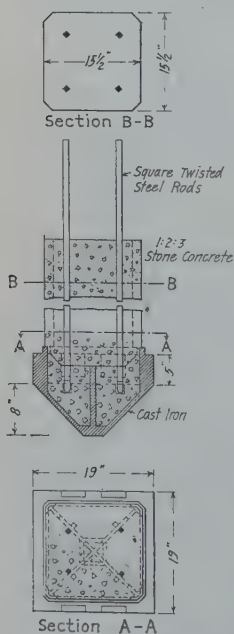


FIG. 5. THE BIGNALL (PATENTED) PILE.

this means two separate jet processes are carried on simultaneously. The 2-in. pipe operating under high pressure delivers a jet stream in the usual way at the point of the pile, while the various $\frac{3}{4}$ -in. connections permit water at a somewhat less pressure to escape upwards along the four faces of the pile, thereby destroying all frictional resistance and permitting the pile to sink into place by its own weight. This type of pile is usually handled by a derrick or crane, and no pile driver or hammer is deemed necessary. On the reconstruction of the Platte River

Bridge of the C., B. & Q. Railroad, at Ashland, Neb., piles of this type were used. They were 15 in. square in section, 50 ft. long, and weighed 6.2 tons. Two independent pumps were operated, one to give a nozzle pressure of from 200 to 300 lbs. per sq. in. and the second to deliver water to the side jets at from 100 to 150 lbs. per sq. in. It is reported that the average time of sinking a 50-ft. pile in this manner was forty-two minutes. The piles are reported to have cost 53 cts. per lin. ft. to manufacture, and 15 cts. per lin. ft. to sink. The total estimated cost of the completed pile was \$1.00 per lin. ft. for piles not to exceed 50 ft. in length. It seems probable that this method of sinking might be quite satisfactory in certain classes of material, such as sand and gravel. There might, however, be some question of the sufficiency of the jet method alone in many materials such as clay and hard pan or some classes of rough fill.

The Giant Pile.



The "Giant" pile (Fig. 6) is patented and controlled by the Giant Concrete Piling Company, of New York. Its patentable feature lies principally in the method of driving the pile. A cast-steel point is built integral with the pile. The upper flanges of this point project about $1\frac{1}{2}$ inches beyond the concrete faces of the pile itself. A driving frame, consisting of two channel irons incasing two sides of the concrete pile for their entire length, rests at the bottom upon the projecting edges of the cast-steel shoe. A specially designed head is attached to the channel iron frames and receives the blows of the hammer. By this means

FIG. 6. THE GIANT (PATENTED) PILE.

the entire force of the hammer blow during driving is transmitted directly to the cast-steel shoe, and no strains are induced in the concrete itself. When the piles are driven, the channel iron frames are withdrawn, to be used again on the next pile. The space which is left in the ground when the frames are withdrawn must be filled by the closing in of the soil against the surface of the concrete pile. Undoubtedly this arrangement permits of very severe driving without endangering the integrity of the pile itself. While it is probable that in a majority of cases the surrounding soil will close around the pile after the frames are withdrawn, it may be considered problematical whether the apparent friction observed in driving is reproduced after the frames are withdrawn.

METHOD OF MANUFACTURE OF PRE-CAST PILES.

Pre-cast piles are usually concreted in a horizontal position. In some of the earlier instances it was deemed necessary to cast them in vertical forms in order that the stratification of the concrete might be normal to the direction of the load. This method of manufacture, however, adds very considerably to the cost of the pile, and it is very doubtful in the writer's opinion whether there is any compensating advantage. It is the almost invariable custom in pile making to use a wet mixture of concrete which has very little if any stratification. It seems likely that, in cases where additional strength is required over that obtained on the ordinary horizontal method of casting, it might be more economically obtained by increasing the richness of the mixture rather than to adopt the very expensive method of casting in vertical forms.

Because of the ease and simplicity of form construction, the square section of pile has become, generally speaking, the most popular (Fig. 7), although hexagonal and octagonal shapes are still used (Fig. 8), but only to a limited extent. The square section also commends itself because of the greater surface area exposed to friction. If for any reason a circular section is desired, it can sometimes be secured by selecting a casting yard having a pronounced inclined slope so that the angle of the forms

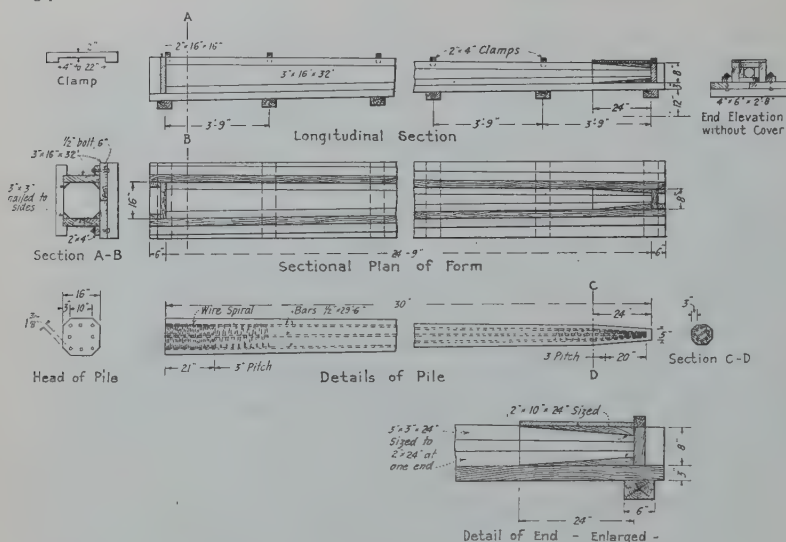


FIG. 7. PRE-CAST CONCRETE PILE (SQUARE) AND FORM.

will permit pouring through the end, otherwise vertical forms will be necessary.

Because of the requirements of a homogeneous mixture of concrete and early strength, pre-cast piles are seldom or never made with a mixture leaner than 1, 2 and 4, and occasionally a richer mix is deemed advisable. It is safe to say, however, that by far the great majority of pre-cast piles are now made of the first-named mixture.

It will be found desirable, in any given case, to devote a considerable amount of thought to the design and construction of the form work used in casting concrete piles. Above all, it is essential that an unyielding base should be provided under the forms, so that unequal settlements will not cause damage to partially set piles. Various and ingenious contrivances and

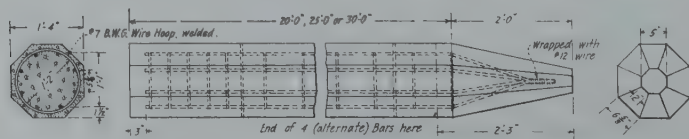


FIG. 8. PRE-CAST OCTAGONAL PILE.

arrangements of form work have been designed from time to time. Figs. 9 and 10 illustrate typical cases.

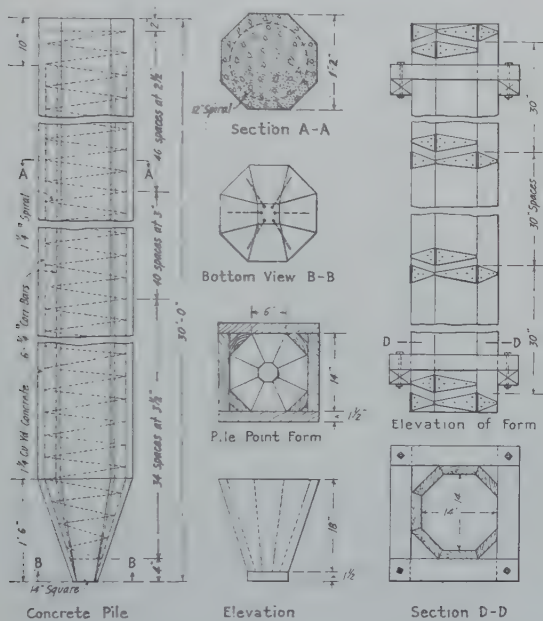


FIG. 9. FORM FOR CASTING CONCRETE PILE.

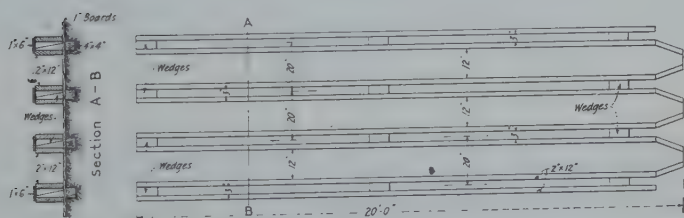


FIG. 10. ARRANGEMENT OF FORMS FOR CASTING CONCRETE PILES.

The fabrication of the reinforcement should also have careful attention. A simple contrivance for economically preparing spiral hooping is shown in Fig. 11. Extreme care is absolutely essential in placing the reinforcement. The reinforcing metal

is usually assembled as a unit so that it may be lowered into the form and accurately centered before the placing of the concrete begins. If a metal point is to be used, it is fitted in place in the end of the form prior to concreting. The sides of the forms can generally be removed in from twenty-four to forty-eight hours after casting, and are then available for use in subsequent forms. Under normal weather conditions, pre-cast piles do not acquire sufficient strength to permit of handling or driving inside of twenty-eight to thirty days after casting. This feature necessitates the use of a very considerable area as a casting yard in order to maintain a sufficient number of properly cured piles

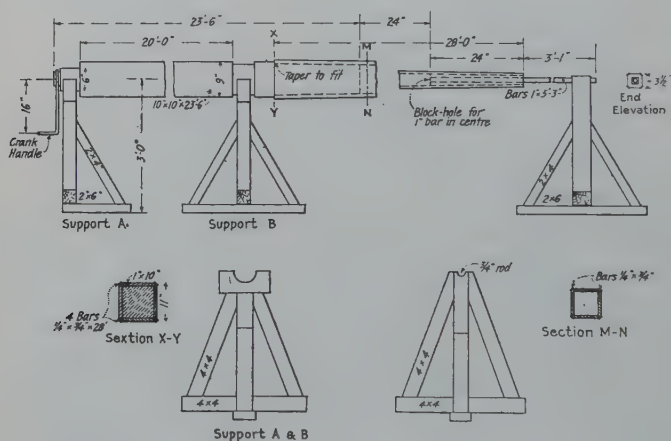


FIG. II. MANDREL FOR WINDING WIRE COIL FOR REINFORCING CONCRETE PILES.

for driving at all times. It has been found that the proper ageing of pre-cast piles may be materially accelerated by the adoption of steam curing methods. The piles are assembled in tiers and enclosed with some suitable form of covering under which live steam is fed continuously. The combination of heat and moisture hastens the set of the concrete without injury, so that they may be handled and driven in some cases within a week of the time of casting.

Unless piles are adequately reinforced to resist rough

handling in the preliminary stages of the work, a considerable degree of care is necessary in moving them to the driver and in raising them to a vertical position (Fig. 12). While piles in lengths up to 25 or 30 ft. may be designed to stand readily a maximum stress due to handling, it will be seen that the longer lengths would require cross-sections of prohibitive dimensions if this provision were to hold in their case. It is, therefore, usually necessary in the handling of long piles to use special



FIG. 12. HANDLING 51-FOOT PILE WITH CENTER SUPPORT ONLY.

precautions which will relieve the pile from undue strain. This is generally possible by means of multiple supports during the lifting and righting operations. In the case of piles measuring from 30 to 50 ft. in length, it will be found possible to handle the pile successfully by means of a bridle chain attached at one point near the head and the other near the center of the pile (Fig. 13). In lifting, the strain is thereby distributed at the two points, and as the pile is raised into a vertical position no excessive force at any time operates to overstrain the steel or concrete. Piles in excess of 100 ft. in length and measuring

20 in. by 20 in. in cross-section have been successfully handled by similar methods except that two bridle chains were used,



FIG. 13. RAISING PILE TO VERTICAL POSITION.



FIG. 14. BRIDLE CHAINS FOR HANDLING LONG PRE-CAST CONCRETE PILES.

permitting support at four points on the pile (Fig. 14). The rule which seems to be in most common use for lifting long piles has been to attach the hoisting falls at points 20 per cent. of the pile length from either end (Fig. 15). In some cases it has been found convenient to insert pipe nipples transversely through the pile section at the points where the lifting strain is intended to be applied (Fig. 16). A pin or bar may then be inserted in the hole thus formed, which assures the application of the lifting strain at the desired point.



FIG. 15. BRIDLE CHAINS FOR HANDLING CONCRETE PILES.

One of the drawbacks in the way of using concrete for the purpose of piling is the inability of the material to withstand heavy direct blows without fracture. This difficulty, however, has been largely overcome by the introduction of certain protecting devices which either resist the breaking stresses or cushion the blows to such an extent that the hammer impact has no harmful effect. Naturally much energy is lost by the introduction of this cushion between the hammer and pile head, there-

fore the least cushion required, the more effective the hammer blows become in causing penetration. For this reason many designers of pre-cast piles introduce additional reinforcement in the head of the pile. In the construction of the St. Louis Viaduct, steel bands 12 in. by 12 in. by $\frac{1}{8}$ in. were cast integral with the head of each pile. Although there had been much breakage of pile heads on this job prior to the adoption of this banding method, no breakage occurred in the case of subsequent piles. At the normal price of steel plate, this form of protection would add not more than four cents per linear foot in the case of 25-ft. piles. The "Cummings" pile, as previously noted, is especially reinforced in a most effective manner against breakage at the

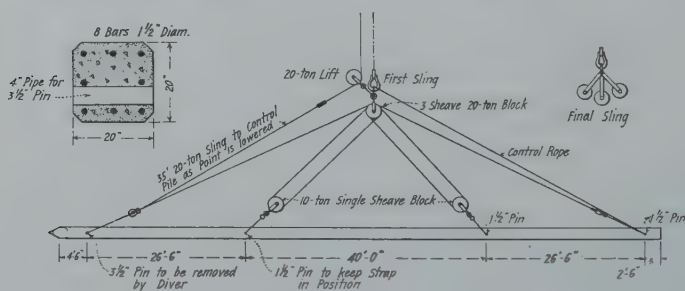


FIG. 16. METHOD OF SLINGING 100-FOOT CONCRETE PILES USED AT AUCKLAND, NEW ZEALAND.

head. Even in these cases, however, if hard driving is required, some form of cushion will nevertheless be required if damage to the pile is to be entirely avoided. Various types of driving caps have been devised for this purpose, and the essential features of all such caps are similar. They are made of steel or cast iron, and contain a recess in the bottom which fits the head of the pile, and a depression in the top in which is usually inserted a hard wood block to receive the blows of the hammer. Between the wooden block and the head of the pile is placed a layer of some cushioning material such as sawdust, sand, rope mats, or layers of rubber hose or belting. In general, the cast-iron caps seem to have given the most satisfactory service, and where the cap has been made of riveted steel plates there has seemed

to be more or less difficult due to the loosening and shearing of the rivets. The wooden blocks require frequent replacement, but otherwise the cap is used continuously. It is customary to equip these caps with a wire-rope strap, by means of which they may be temporarily attached to the hammer and thus raised or lowered from the pile head. It is also desirable to construct the cap with some form of grooves which fit the leads of the pile driver and thus cause it to guide the head of the pile. Details of construction of various types of driving caps are shown in Figs. 17, 18 and 19.

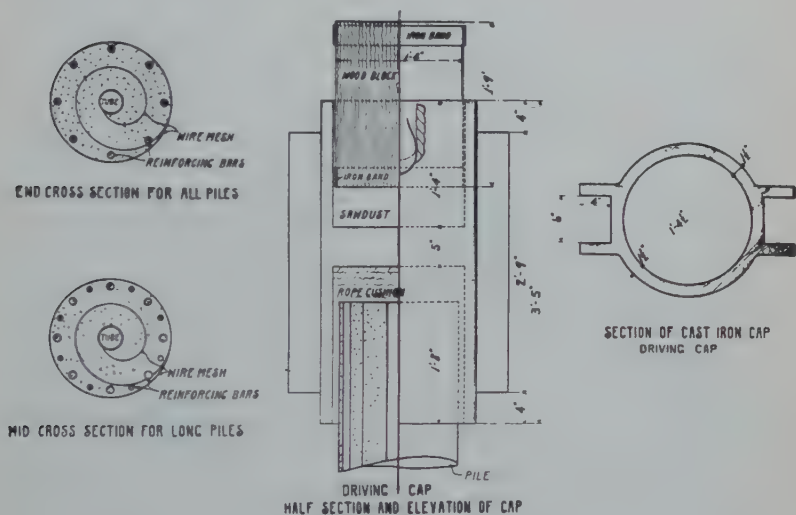


FIG. 17. TYPE OF DRIVING CAP.

There has been much controversy as to the type of hammer best adapted for driving concrete piles. Some authorities have maintained that the drop hammer is superior for the purpose to the steam hammer. Other experienced pile drivers maintain that the steam hammer excels, and among the steam hammer adherents there is some disagreement as to whether the single or the double acting hammer is to be preferred. After a consideration of all the arguments pro and con, on this question, it seems reasonably safe to assume that, whichever type of hammer

is used, the heavier it is the more successfully it will drive the pile. Because of the great mass of the pile itself, it is obvious that a large proportion of the force of the hammer blow will be expended in overcoming its inertia; therefore light hammers of either variety should be avoided in the driving of concrete piles. It seems to the writer a significant fact that, in the very great majority of concrete pile-driving jobs, the steam hammer is selected in preference to the drop hammer, and it would appear

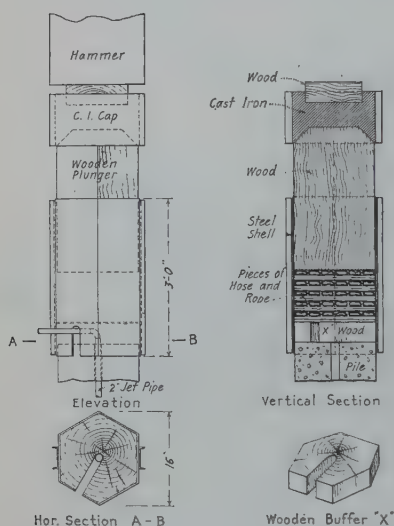


FIG. 18. TYPE OF
DRIVING CAP.

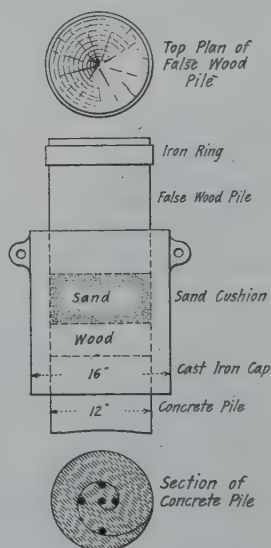


FIG. 19. TYPE OF
DRIVING CAP.

to be a fair presumption that it must on the whole, therefore, possess advantages over the drop hammer.

As to the double-acting steam hammer, it has not apparently enjoyed any considerable degree of popularity in the driving of concrete piles up to this time. It is reported that, in the driving of concrete piles for the St. Louis Viaduct, a 5 000-lb. double-acting steam hammer was used at the beginning, and much difficulty was experienced because of the frequent breaking of pile heads. Finally the ram itself was broken, whereupon a

No. 1 Vulcan 10 000-lb. single-acting hammer, with a 5 000-lb. ram and a $3\frac{1}{2}$ -ft. stroke, was substituted, and no further difficulty from breakage was experienced. The progress with the double-acting hammer had averaged 9 piles per day, and this output was increased to 17 per day after the introduction of the heavier single-acting hammer. With regard to the breakage of pile heads referred to, it is not clear why the type of steam hammer should cause such a difference, and it seems possible that the subsequent immunity from breakage might more properly be attributed to the use of the steel bands previously referred to in connection with these piles. The economy of the heavy over the light hammer, however, is well illustrated by the increased progress shown in this instance. The heaviest hammer so far used for this purpose was employed in driving pre-cast piles for Pier No. 2 of the Intercolonial Railway, at Halifax, N. S. The piles were 24 in. square, 57 to 77 ft. long and driven to rock, the largest pile weighing 23 tons. A 28 000-lb. double-acting steam hammer was used in driving them. From 200 to 1 800 blows were required to drive these piles to rock, final penetration being $1/30$ in. It is reported that only two pile heads were broken, out of the 1 800 piles which were driven on this job. The heads of the piles were protected by 3-in. spruce planks, upon which rested a cast-steel follower of hollow pattern and with top and bottom flanges. The top flange contained a depression in which was placed a wooden block 15 in. thick and bound with steel bands. Some blocks lasted for the driving of only two piles, while others served as many as twenty. They usually failed by the bursting of the bands. An average of 10 piles in ten hours was maintained on this work, with a maximum rate of 18.

In all cases where a drop hammer is used, the best results may be expected by employing as heavy a hammer as possible and using a small drop.

Another question which appears to remain somewhat unsettled is that of the relative merits of the straight and tapered pile. Undoubtedly the tapered pile may be driven more easily than the straight pile, especially when the water jet is not employed, and it also seems reasonably clear that if the entire length of the pile rests in a homogeneous material, the tapered pile may

give equally satisfactory results as a support for the load it carries. The fact is, however, — no matter how much we may theorize, — that the primary object in using piles ordinarily is to carry the load through an unsatisfactory type of soil and transmit it to some more reliable stratum at a lower depth. It is not, generally speaking, conservative practice to attach any value whatever to the frictional supporting power of the unsuitable strata immediately below the surface, and, as a matter of fact, we are chiefly dependent for our supporting power upon the amount of penetration which the pile has in the good material below. It seems, therefore, to be highly desirable that the pile shall have its maximum section and frictional surface area at this level where it will do the most good. The writer is, therefore, inclined to agree with the adherents of the straight-sided pile. This, of course, does not preclude the tapering of piles at the point or even a short distance above the point, and in many classes of soil such pointing is desirable in order to facilitate easy driving. It cannot be denied, of course, that tapered piles have been successfully driven in innumerable cases with entirely satisfactory results, but in the writer's estimation this of itself does not justify an opinion that they are superior in supporting power to the straight pile, the displacement of which is greater, the soil compression consequently being greater, and the resulting surface friction between the ground and the pile being also, in his opinion, much in excess of that of the tapered pile.

It has become a more or less general practice, in the driving of concrete piles, to utilize the assistance afforded by the water jet as an aid to rapid and effective driving. This expedient is especially helpful when the material through which the pile is driven consists of sand or gravel, materials which offer a maximum of resistance in their normal state and which present little resistance when eroded by the force of a powerful water jet. The efficiency of this jet in driving through clayey soils is not so marked, and much greater force is required to displace this material. Ordinarily, a pressure of from 100 to 150 lbs. per sq. in. is ample for jetting piles. As previously indicated, it is sometimes customary to provide a water passage by means of a

pipe or other longitudinal opening through the center of the pile. The delivery hose from the hydraulic pump may then be attached at the top of the pile to deliver the water through a nozzle at the point. Some authorities maintain that better results are obtained when two jet pipes are used on opposite sides of the pile. A committee of the American Railway Bridge and Building Association has recently compiled information with respect to the methods adopted by various railways in driving piles. The use of the water jet was found to be more or less general, and was used chiefly in sandy or gravelly soils or where deep penetration is required. It was found that the jet pipes used varied in sizes from $2\frac{1}{2}$ to $1\frac{1}{4}$, and nozzles from no contraction to $\frac{1}{2}$ in. in diameter. The water pressure used varied from 100 to 225 lbs. per sq. in., and pumps with 3-in. to 4-in. diameter discharge pipes were generally used. A large volume of water at moderate pressure was stated to give the best results. It was also reported that on the St. Paul, Minneapolis & Omaha Railway a steam jet was sometimes used in place of water. This method was found to work satisfactorily.

When a water jet is employed in connection with the driving of concrete piles, it will be found advantageous to churn the pile up and down in the hole made by the jet. In such cases the hoisting fall of the pile driver is attached to the head of the pile, the jet pump started, and when the jet has begun to operate, the pile is lifted 2 or 3 ft. and allowed to drop of its own weight. In this manner the soil is scoured from below the pile and softened to such an extent that it permits the falling pile to penetrate a substantial distance at each drop. In sandy soils it is usually possible to sink a pile for the greater part of its length in this manner, and driving is then only required for the last few feet of penetration (Fig. 20).

In some instances, where the soil possesses some cohesion, it will be possible to make a vertical hole in the ground with the jet alone into which the pile may be dropped for the greater part of its length. This method will be quite applicable when the soil is composed of fine sand with a slight amount of clay in it.

It is often desirable, in wharf or pier construction where piles are subjected to the force of the waves, to anchor them in

some manner which will prevent their becoming loosened. With this idea in mind, bulb-shaped footings 3 ft. in diameter and attached to concrete piles have been successfully jetted into place through sand.

Sometimes it becomes necessary to drive concrete piles through very rough material containing bowlders or other obstructions. In such cases a small-sized pilot pipe may be driven



FIG. 20. SINKING PILE BY WATER JET AND "CHURNING."

into the ground until it meets the obstruction. A charge of dynamite may then be inserted and exploded with the purpose of breaking up the rough ground and permitting the pile to be driven through it.

BEARING POWER OF PRE-CAST PILES.

The supporting power of a pre-cast pile will depend upon a variety of factors. If the piles are driven to ledge, they become columns, so far as their load capacity is concerned, except

that in general they are supported against lateral deflection and also they undoubtedly transmit at least a portion of their load by means of friction to the soil above the ledge. In such cases the load should be apportioned to the piles in proportion to the safe compressive value of their minimum sectional area. If the amount of penetration of the pile in good material is small, it will be seen that a tapered pile figured as a column will suffer in comparison with the straight pile so far as its safe supporting value is concerned. It is sometimes customary to figure the aggregate capacity of a column pile as equal to the combined safe compressive values of both the steel and concrete in its sectional area. Figured on this basis, it will be apparent that a pile of relatively small sectional area may be permitted to carry a very considerable load as a column, secured as it is against lateral deflection. It has already been stated that the piles for the Halifax Terminal Pier, which were 24 in. square in cross-section and up to 77 ft. in length, driven to rock, were loaded with 100 tons each. The same considerations which apply to pre-cast piles bearing upon ledge may with slight modifications be assumed to hold in cases where the pile is driven to an unyielding hardpan overlying ledge. In either of these cases it will be obvious that the straight pile is superior to the tapered pile in point of safe carrying capacity.

When the supporting power of the pile depends entirely upon its frictional contact with the surrounding soil, there is far less certainty as to either its ultimate or safe load capacity. The same theory is usually applied and the same formula generally followed as in the case of wooden piles. The so-called *Engineering News* Formula, $L = \frac{2 Wh}{S+1}$, where L equals the safe load in pounds, W equals weight of hammer in pounds, h equals fall of hammer in feet, and S equals penetration in inches under the last blow, has been extensively employed to determine the safe load which the piles are capable of supporting. There is an essential difference, however, between the wood and concrete piles which doubtless requires some modification of this formula. The relatively large mass of the pile itself consumes a considerable portion of the energy

of the blow in overcoming its inertia. It has been suggested by some authorities that the *Engineering News* Formula, if used, should be modified so as to take into account this factor, and the particular formula which has been proposed is
$$L = \frac{2 Wh}{S \left(1 + \frac{w}{W} \right)},$$

where w equals the weight of the pile and W that of the hammer. The formula for single-acting steam hammer which has been generally adopted, viz., $L = \frac{2Wh}{S + .1}$, should presumably be similarly modified, in the case of concrete piles, to
$$S \left(1 + \frac{.1 w}{W} \right).$$

All formulae which have so far been proposed in connection with the use of the double-acting hammer are more or less unsatisfactory because of the difficulty of accurately determining the mean average steam pressure during the downward stroke of the piston. It probably would be safe in any event not to rely too much upon formulae for load capacity, but to decide the question upon the results of observed tests and apply the results thus obtained to the formulae in order to secure a coefficient which may be made to apply to the driving of subsequent piles on that particular job or under similar conditions. In case actual loading tests are not made, it will probably be well to limit the allowable load on ordinary types of concrete piles to a maximum of thirty tons. This assumed value seems justified in view of the fact that the various available records of test loads upon concrete piles having a reasonably good penetration into satisfactory soil have failed to disclose any failures due to settlement under loads below this amount.

RATE OF PROGRESS IN DRIVING PRE-CAST PILES.

No rule can be laid down for determining in advance the probable progress to be expected in the driving of pre-cast concrete piles. Just as various attending conditions will vary the rate of progress in the driving of wooden piles, so also the number of concrete piles which may be driven in a given period will fluctuate accordingly. Undoubtedly the use of the water

jet has a marked influence in increasing the rate of driving. So also does the adoption of the heavier types of hammer. Even with these facilities, soils are often encountered which refuse to yield appreciably under their influence and recourse must be had to long-continued driving with small increments of penetration. Generally speaking, however, under the most severe conditions of driving, and taking a 25-ft. pile as a fair average of length, not less than six piles may be estimated as a day's work, while, with favorable conditions, as many as thirty to forty such piles have been driven by a single machine in one day. It may be assumed, therefore, that the expected daily average will lie somewhere between these limits; and with a prior knowledge of local conditions it will usually be possible to classify the relative difficulties so as to determine approximately what the probable output is likely to be.

PRESENT GENERAL PRACTICE IN THE DESIGN OF PRE-CAST PILES.

The Masonry Committee of the American Railway Engineers Association reported, about a year ago, on the current practice of several railroads in their reinforced concrete pile construction. It stated, among usual customs, that the transverse reinforcement used was generally $\frac{1}{4}$ -in. rods, arranged either as a spiral or spaced hooping. Steel wire mesh was used for reinforcement in a few cases, and additional steel was sometimes used in the pile head. The weight of the steel per linear foot used by the several railroads ranged from $4\frac{1}{4}$ lbs. on the C., B. & Q. Railroad, to $12\frac{1}{2}$ lbs. on the Illinois Central and $17\frac{1}{2}$ lbs. on the Chicago, Milwaukee & St. Paul Railroad. Usually, 16 in. was the short diameter adopted, whether the section was square or octagonal. The Atchison, Topeka & Santa Fé Railroad used the formula $D = 7'' + \frac{1}{4}'' \times L$, where L equaled the length in feet and D the diameter of the pile in inches. The use of straight piles was found to predominate over the tapering type.

COST OF PRE-CAST PILES.

In common with all classes of underground construction, the cost of reinforced concrete piles varies with design and conditions. The cost of materials for any given case may usually

be determined with reasonable accuracy for any given locality. The labor cost of making and driving will vary widely, depending upon various contributory causes.

On the St. Louis Viaduct work, where the piles were $13\frac{1}{2}$ in. square and 25 ft. long, four $\frac{3}{4}$ -in. round bars hooped with No. 8 spiral wire on 2-in. pitch were used as reinforcement. The labor making up the unit reinforcing cages cost from \$1.00 to \$1.25 per pile, with labor at 65 and 70 cts. per hour. The cost



FIG. 21. HANDLING AND DRIVING CONCRETE PILES.

of labor for casting these piles was 8 cts. per lin. ft., with labor at 40 cts. per hour. On the construction of the Yolo Bypass Trestle in the Sacramento Valley, Cal., 14-in. piles 32 to 50 ft. long were used, and the average cost of assembling and placing reinforcement, consisting of four $\frac{7}{8}$ -in. round rods with spiral hooping, was \$7.50 per ton. An average of 20 piles per day were cast, and 600 sets of forms were required, there being a total of slightly under 3 000 piles; 177 000 ft. board measure of lumber was used for forms exclusive of mud sills. The cost

of loading and hauling piles on a 3-ft. narrow-gage track for an average distance of $2\frac{1}{2}$ miles was 7.3 cts. per ton mile FOR LABOR ONLY.

The writer on one occasion kept a careful record of the cost of making and driving 412 concrete piles ranging in length from 8 to 40 ft. They were cast with a 13-in. square section reinforced by a cage of No. 3 Clinton Wire Cloth placed 2 in. from the outer surface. They were sunk with the assistance of a water jet introduced through a hole in the center of the pile formed by casting a line of $1\frac{1}{2}$ -in. speaking tube in the longitudinal axis. The concrete mixture used was 1, 2 and 4. The soil consisted of mud, fine sand and some floating masses of clay hardpan. The piles were cast under cover in a sectional shed which was moved from time to time as required. They were handled by guy derricks, were held in upright position by a light portable timber framework which contained a pair of hammer leads, and were driven with a 2 800-lb. hammer operated by the derrick falls. (Fig. 21.) Twenty piles was the maximum day's work. A sounding was taken at the location of each pile, to determine accurately the necessary length of the pile in order that it should reach ledge. There was a total of 8 937 lin. ft. of piles cast and driven. The cost of the work in detail was as follows:

	Per Lin. Ft.	
Labor making soundings.....	\$0.02	
Labor on forms.....	.035	
Labor casting, including placing reinforcement.....	.129	
Labor driving.....	.142	
Labor, Superintendent and miscellaneous.....	.128	
		\$0.454
Materials for forms.....	.036	
Clinton wire reinforcement, \$0.05 per sq. ft.....	.167	
$1\frac{1}{2}$ " speaking tube for center jet hole.....	.026	
Concrete aggregates.....	.212	
Materials used for heating and covering.....	.025	
Ropes, blocks, chains, etc.....	.044	
Coal.....	.023	
Miscellaneous supplies.....	.042	
Total for materials and supplies.....		\$0.575
Total cost for labor and materials.....		\$1.029

As this work was prosecuted in the winter time, it was somewhat more expensive than it otherwise would have been. The price per hour for labor at the time this work was done averaged about 20 cts.

Under the most favorable conditions it is unlikely that any pre-cast pile can be made and driven to-day at a contract price below \$1.00 per lin. ft., and the cost is likely to range from this minimum to a maximum of \$1.50.

NOTABLE INSTANCES OF THE USE OF PRE-CAST CONCRETE PILES.

In addition to the case cited of exceptionally heavy concrete piles used at the Halifax Terminal Pier of the Intercolonial Railway, where piles upwards of 77 ft. in length and weighing 23 tons were successfully handled and driven, it may be noted that pre-cast piles of a maximum length of 106 ft. and 20 in. square were driven in the construction of Pier No. 35 of the San Francisco Harbor Development. This extreme length was made necessary because of the very considerable depth of alluvial deposit. These piles were designed to carry 40 tons each. Pre-cast piles 85 ft. in length and 20 in. square were used in the construction of piers in Havana Harbor in 1914. They were driven by a No. 1 Vulcan steam hammer, with an average of 500 blows per pile, and brought up with a penetration of $\frac{1}{8}$ in. They also were designed to carry a load of 40 tons per pile. Pre-cast piles 100 ft. in length were used in the construction of wharves at Auckland, New Zealand. They were driven through 50 ft. of mud and clay to rock. These piles were 20 in. square, reinforced with 8 long rods and weighed a maximum of 20 tons.

So far as the writer is aware, there have been reported no failures on the part of pre-cast piles to fulfill their intended purpose as foundations. In his opinion, considered solely from the standpoint of efficiency, the pre-cast pile is superior to the other types. They possess, however, some serious disadvantages which render their use less common than it would otherwise be. With the modern tendency to hasten construction at every stage, the loss of time necessary to permit pre-cast piles to be properly made and cured renders their use prohibitive in many instances. Ordinarily it may be assumed that at least one month will be

required after the work is begun and before actual driving can commence. As previously stated, this period may be very materially shortened by adopting the steam curing method when adequate means are available. A second serious drawback which limits the use of pre-cast piling, especially in congested districts, is the necessity of providing a very considerable area for a casting yard. In the case of the ordinary city building work it is seldom possible to set aside a sufficient area for this purpose, and therefore, if pre-cast piles are to be used in such instances, they must be made at another point and transported to the building site as required. A very ingenious and efficient



FIG. 22. CASTING YARD FOR CONCRETE PILES.

arrangement for reducing the space necessary for a casting yard is shown in Figs. 22 to 26. This system was devised and used by Mr. W. L. Miller, of Boston, in connection with a concrete-pile contract for a pier at Baltimore, Md. It will be noticed that the casting yard is long in proportion to its width and that a traveling bridge or crane spans the space occupied by the piles. Its power equipment is located at one end of the trussed frame, while the concrete mixing plant is integral with the opposite end. By means of a long shaft, the crane is propelled longitudinally of the casting yard so that it may readily cover any section. This traveling gantry was used to handle forms, reinforcement

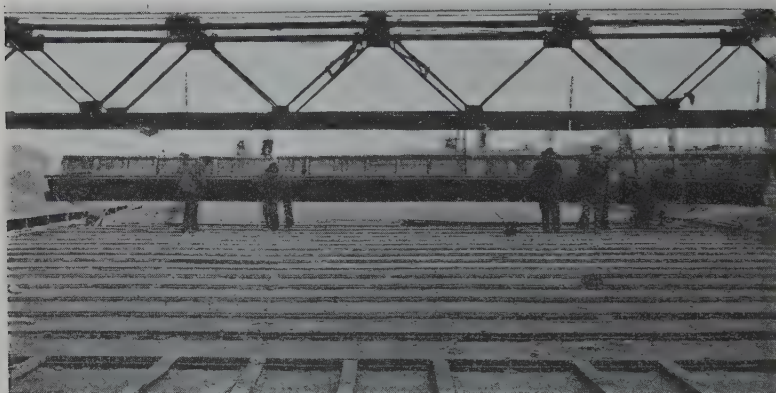


FIG. 23. CASTING YARD FOR CONCRETE PILES.
(Handling forms.)

and concrete, and, what is of still more importance, it was utilized to nest the partially cured piles in tiers so as to economize in space.

CAST-IN-PLACE PILES.

Because of the unsuitability of pre-cast piles for the conditions oftentimes met with, there have been introduced a



FIG. 24. CASTING YARD FOR CONCRETE PILES.
(Handling reinforcements.)



FIG. 25. CASTING YARD FOR CONCRETE PILES.
(Placing concrete.)

variety of ingenious methods for constructing concrete piles in place. This method obviates the necessity of a large casting yard and of the preliminary delay necessitated because of the initial curing period.



FIG. 26. CASTING YARD FOR CONCRETE PILES.
(Handling piles.)

The Raymond Pile.

The first pile of this type to be introduced in the United States was the "Raymond" pile, invented in 1896 by Mr. A. A. Raymond. This pile was first used in Chicago in 1901 (Fig. 27).

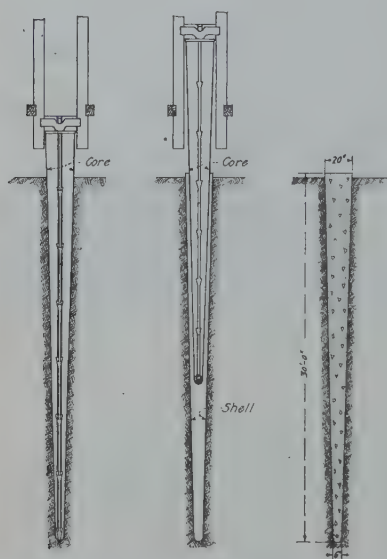


FIG. 27. THE RAYMOND PILE.
(Built in place.)

It consists of a light, sheet metal tapered shell approximately 20 in. in diameter at the top and 6 in. at the bottom. This shell is fitted over a collapsible mandrel or core. The mandrel and shell are driven simultaneously by means of a heavily constructed pile-driving apparatus, and, when a satisfactory minimum penetration has been secured, the core is collapsed by an ingenious contrivance so that it may be withdrawn, leaving the shell to retain the surrounding earth while concrete is deposited within it.

The shell is usually built in 8-ft. lengths in such a manner that each succeeding section will lap the preceding one. The shells first used were of No. 18 or No. 20 gage, and it was frequently found that the reaction of the soil was sufficient to collapse this light metal wall after the core was withdrawn and before the concrete filling could be placed. In such cases it became necessary to drive additional shells inside the first until a combined strength sufficient to withhold the soil pressure was obtained. To obviate this difficulty, the type of shell was altered, some years ago, in a manner which permitted the use of No. 24 gage metal corrugated spirally, while in the corrugations was placed $\frac{1}{4}$ -in. steel wire which not only resisted the collapsing pressure of the surrounding soil, but in addition served as a spiral hooping around the concrete.

The cores first used were made in three longitudinal sections which were expanded by means of a central longitudinal rod with connecting links. As this device was somewhat delicate for the rough usage accorded it, a more substantial type of core was later devised, consisting of two heavy semicircular longitudinal sections with a flat center strip between them containing wedge-shaped wings which forced the two halves of the core apart or drew them together as might be desired.

The advantages of this type of pile are found in the readiness with which its interior may be inspected before filling and the rapidity of progress due to the fact that the pile driver may proceed with the driving of a second pile while the first one is being filled with concrete. The concrete is protected by the spiral reinforcing against lateral strains during its period of setting. Reinforcing bars may be inserted before or during the concreting operation if desired, but this is seldom deemed necessary.

Among the objections urged against this type of pile are the following:

Because of its pronounced taper, a section of comparatively small area penetrates the firm soil upon which chief reliance is placed for supporting the load. This is especially objectionable when the pile is driven to rock or other very hard strata, and in almost every case the larger proportion of the surface area of the pile will rest in unreliable top material. It is also urged that there is some danger, while withdrawing the core, of the shells being started upward with it. Because of their pronounced taper, such an occurrence even though small in amount would destroy the frictional contact between the shell and ground. This does not seem to the writer a very probable occurrence or necessarily serious one, unless by chance the bottom section should be so withdrawn and thus remove the bearing at the tip. These piles have been driven up to 45 ft. in length.

The Simplex Pile.

In 1903 there was introduced in this country a built-in-place pile known as the "Simplex" pile (Fig. 28), the invention of Mr. Frank Shuman, of Philadelphia. It consisted at that time

of a pre-cast concrete point resembling somewhat in shape a large projectile approximately 16 in. in diameter, upon which rested a steel cylindrical tube or pipe 16 in. in diameter and of

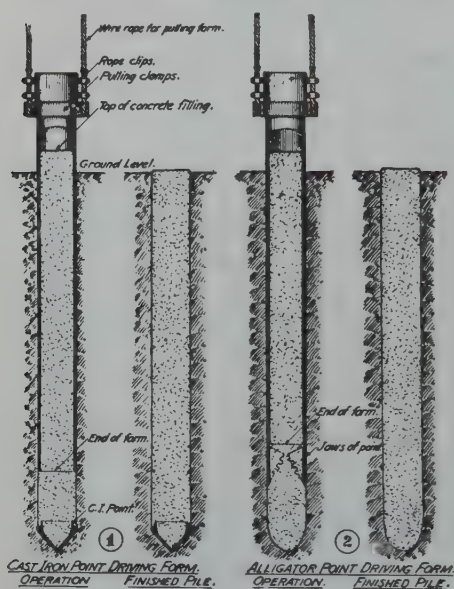


FIG. 28. THE SIMPLEX PILE.

(Built in place.)

sufficient length and strength to permit driving it to the required depth. The point and tube were assembled in a vertical position and driven by an ordinary pile driver to refusal. Powerful pulling tackle was then applied to the top end of the tube, and, as concrete was deposited in the tube, it was gradually withdrawn so that the soft concrete might flow out against the surrounding soil and thus completely fill the space vacated by the tube. The pre-cast concrete point remained in the ground and formed

the tip of the finally completed pile. More or less difficulty was experienced with the concrete points, due to breakage in driving and to the occasional tendency for the point to become driven into the tube and so wedged that it often was withdrawn with it. To overcome this difficulty, a new type of point was devised, which consisted of a conical-shaped steel point of hollow section, split longitudinally, each of its halves being hinged to the lower collar of the tube. With this apparatus the tube was centered in the pile-driver gins, the two halves of the point brought together so as to present a conical point to the ground, and the whole was driven as in the previous case. When final penetration was reached, the tube with this attached point was withdrawn a few feet, and by means of a heavy rammer or weight,

which was lowered through the tube, the two halves of the conical point were forced apart and swung outward, leaving an open passage for the placing of the concrete. The tube was then withdrawn as in the previous case, as the concrete filling progressed. This so-called alligator point, while very ingenious and usually efficient, was found to have a serious drawback in that it was not always possible to obtain the full opening desired. If the halves of the cone, or either of them, failed to open fully, the sectional area was correspondingly contracted and there was danger while pulling the tube that a part of the concrete charge inside might be drawn upward with it, leaving a void which usually would be filled by the surrounding soil, thus destroying the integrity of the pile. In order to prevent such an occurrence, these piles are now driven with a loose cast-steel point which fulfills all of the functions of the two previous types and which is left permanently in place as a pile tip.

This pile has enjoyed a considerable degree of well-earned popularity in various sections of the country, and some notable installations are recorded to its credit. While its use has generally resulted satisfactorily, there have been instances of serious failure due to one or the other of two causes. First, the breaking of the continuity of the pile by occasionally withdrawing a part of the concrete as the tube is raised, and secondly by lateral distortion and displacement due to forces introduced in the soil during driving of subsequent piles. It will be readily seen that where concrete is deposited in a 16-in. tube, unless it is an easy-flowing mixture there is always the possibility of an arching action within the concrete mass which may cause it to adhere to the sides of the tube instead of flowing out and filling the space vacated by the tube during the process of withdrawal as intended. This difficulty can be and usually is provided against by means of careful watchfulness on the part of the foreman and inspector, or by the use of some telltale device which will indicate that the concrete is settling whenever the tube is being withdrawn. The second method of failure is not so easily provided against, nor can it be always readily detected. There appears now to be almost conclusive evidence that certain soils transmit their compression forces in a lateral direction for con-

siderable distances. The influence on surrounding objects, in the adjacent soil which may be subjected to these forces, was well illustrated a few years ago in Cleveland, where the driving of wooden piles for the Clark Avenue Viaduct produced such compressive stresses in the soil as completely to crush an 8-ft. brick sewer although the piles themselves did not come in contact with it. Similarly, during construction of the Fish Pier, at

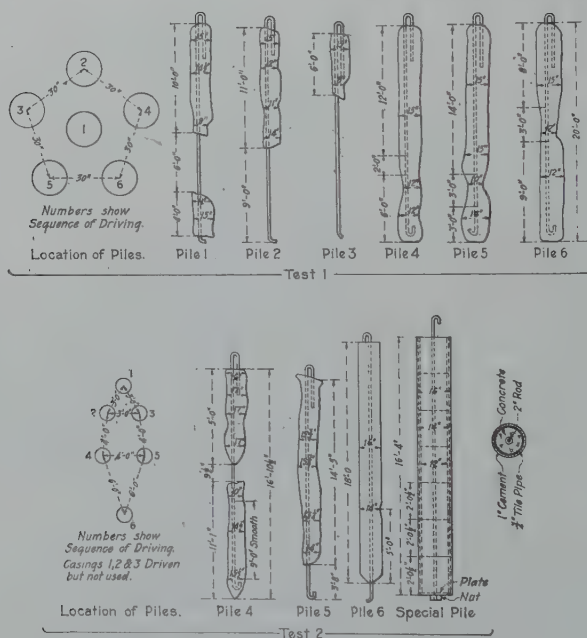


FIG. 29. DISTORTION OF BUILT-IN-PLACE PILES.

South Boston, Mass., a few years ago, the driving of foundation piles for buildings produced a lateral displacement of an exceptionally heavy stone retaining wall surrounding the pier and retaining the pier fill. It is obvious, where such conditions exist in the soil, that the driving of several piles of this type in a group may result in serious distortion and displacement of adjacent piles already driven. With a view to determining whether such distortion would be possible if the tubes were driven for all

of the piles in a cluster before any concrete was placed, Mr. Francis L. Pruyn, of New York, conducted a test about four years ago, wherein he drove six tubes 16 in. in diameter in a cluster, the individual tubes being 3 ft. on centers. After standing twenty-four hours they were filled with concrete and the tubes withdrawn in the usual way. Later on, when the concrete had attained sufficient strength, the piles were pulled out of the ground by means of heavy rods which had been imbedded in

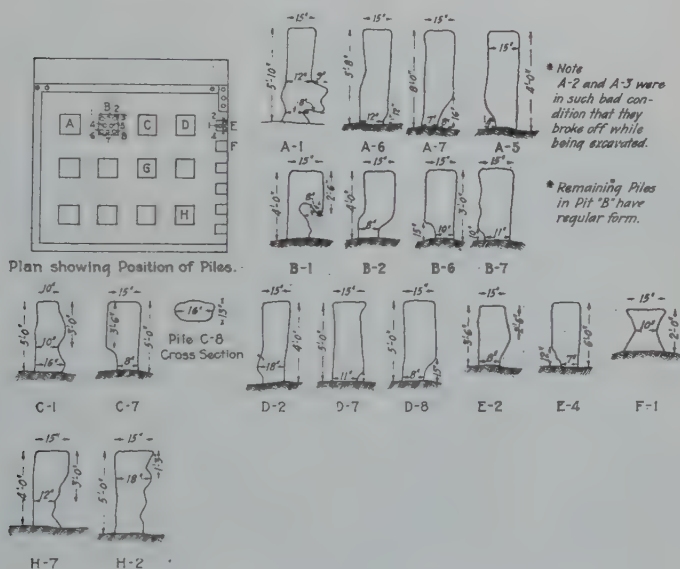


FIG. 30. DISTORTION OF BUILT-IN-PLACE PILES.

the concrete for that purpose, and the appearance of the several piles as then found is shown in Fig. 29. From this test Mr. Pruyne concluded that the pressure set up in the soil by the driving of the tube remained active even after a lapse of twenty-four hours. A similar result from that cause is shown in Fig. 30.

Fig. 31 illustrates the condition of some of these piles as disclosed by excavations made under the foundation of a building in Chicago a few years ago. The settlement of the building required that it should be underpinned to prevent further damage.

This was done by means of open circular wells sunk to hard bottom and located under the building walls. In the sinking of these wells many of the previous piles were uncovered, and their condition is clearly indicated in the illustration by the longitudinal elevations and frequent transverse cross-sections of the well excavations.

Notwithstanding these instances, it must be admitted that with the exception of a few such cases which have occasionally

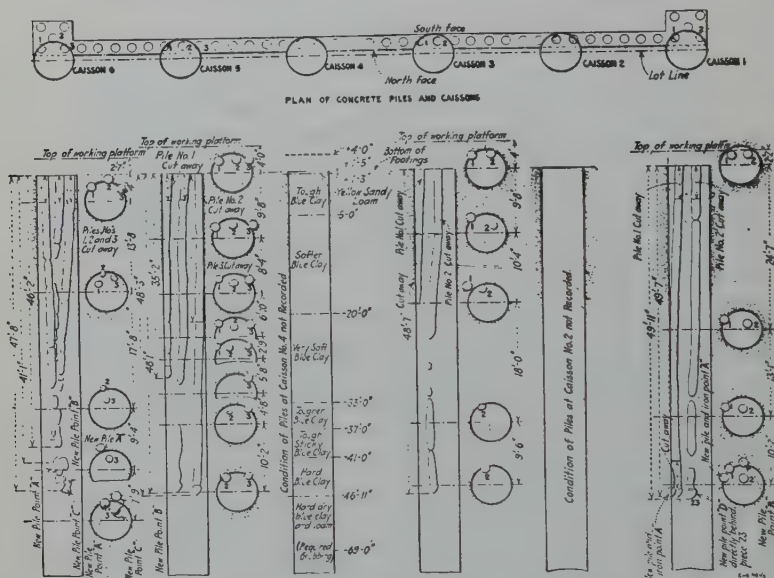


FIG. 31. CONDITION OF BUILT-IN-PLACE PILES DISCLOSED BY EXCAVATION.

come to light, this type of pile has proved uniformly successful and efficient in thousands of installations and under a great variety of conditions, and that test loads which have frequently been applied have usually indicated a remarkable sustaining power. Likewise piles of this type have been uncovered at various times by adjacent excavations and found, generally speaking, to be perfect in shape and condition. It seems likely, therefore, that various soils act differently in respect to the transmission of compressive forces, and it is also reasonable to

suppose that many deformed piles are successfully carrying considerable loads without any indication of their condition. In fact, the very compression of the soil which brings these conditions about may itself be a factor in furnishing adequate support exclusive of the piles, due to its resultant compactness. The rate of progress in the driving of "Simplex" piles is retarded somewhat by the fact that the pile driver must be utilized in pulling the tube during process of concreting, and thus work can proceed on only one pile at a time with a given machine. As the tube is withdrawn, its upper end is elevated so as to require the hoisting of the concrete before depositing.

Very severe strains are brought to bear upon the pile driver because of the enormous power required to start the tubes after they have been driven. Wear and tear on these machines is, consequently, very great, and it is not uncommon to lose a large amount of time on account of repairs to machine and apparatus.

The Pedestal Pile.

The "Pedestal" pile, Fig. 32, was invented in 1909 by Mr. Hunley Abbott, and combines the essential features of the "Simplex" pile with somewhat distinctively individual qualities. Instead of adopting a point on the tube, the "Pedestal" pile employs a solid plunger which occupies the interior of the tube and projects a few feet below the bottom thereof. This plunger is pointed at the lower tip and its top end, and is provided with a collar which rests upon the upper edge of the 16-in. tube. The point, tube and plunger are driven as a unit by an ordinary pile driver. The plunger is then withdrawn, leaving the open-ended tube in the ground with a recess in the soil below. In this recess, concrete is deposited and the plunger is again used, this time as a rammer to force the concrete against and into the surrounding soil with such force that a bulb-shaped footing is formed upon which the body of the pile rests. The tube is withdrawn and concrete deposited as in the case of the "Simplex" pile, the result being a 16-in. cylindrical column resting upon an enlarged base. This type of pile obviously possesses all the advantages of the "Simplex" pile and in addition an

increased supporting power due to the spread footing. In other words, if the "Simplex" type of pile is employed to support a given load, the addition of the bulb-shaped footing will afford that much additional security against settlements. On the other hand, the character, shape and dimensions of the bulb which is formed are matters of speculation and not of certainty. In some soils it is doubtful if a bulb of any appreciable size is formed. In other cases, if the resistance of the soil for any reason is not uniform, the shape of the bulb will follow the direction of least resistance. If the pile is properly driven

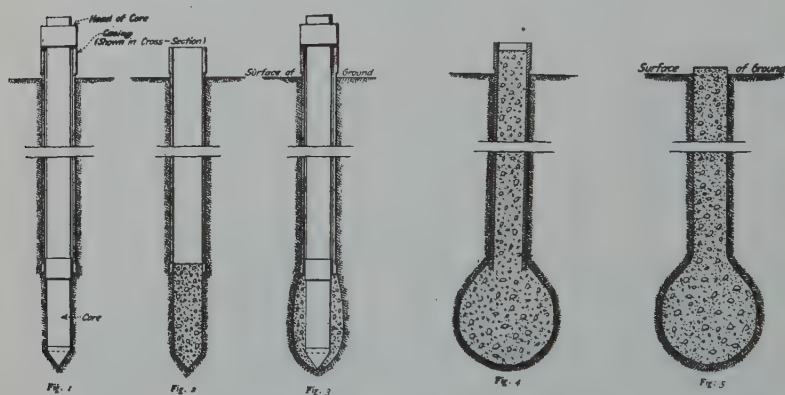


FIG. 32. PEDESTAL PILE.
(Built in place.)

and the stem retains its integrity, the bulb footing is, so far as serving any useful purpose, superfluous. It must be conceded, however, that, in some classes of soft soils which are of a depth in excess of the ordinary available pile length, this bulb footing may be very valuable as an aid in safely distributing the load. This pile naturally possesses all of the disadvantages of the "Simplex" type, especially that due to possible distortion and displacement of its stem.

A group of "Pedestal" piles driven at Long Island City, N. Y., was uncovered by direction of the Building Department, to permit an examination to be made of their condition. This was found to be excellent in every respect. It is reported that

the material in which they were constructed consisted of rubbish fill, muck and sand, the piles being 20 ft. long. It is apparent in this instance, at least, that the rubbish and muck were sufficiently compressible to permit of being displaced laterally without setting up pronounced elastic forces in the soil.

Piles of the "Simplex" and "Pedestal" type cannot be used in semi-fluid material, or in situations where a portion of the length must be constructed in water, because the concrete filling would escape laterally when the tube was withdrawn. It is possible, however, by a slight modification of the method, to meet these conditions when necessary. The heavy driving tube is put down in the usual manner and, after some concrete has been deposited, a light steel shell may be inserted in the tube, filled with concrete and left permanently in place to retain the fresh concrete after the driving tube has been withdrawn.

Peerless Piles.

Another type of built-in-place pile which has recently been introduced is known as the "Peerless" pile, Fig. 33. Short lengths of thin reinforced concrete hollow shells are superimposed upon one another to the approximate length of pile desired. These shells are assembled upon a cast-steel point or shoe, and a heavy plunger or follower is inserted through the hollow interior so as to rest upon this steel shoe. On the upper portion of this plunger is an adjustable collar which overlaps and bears upon the top section of the concrete shell. This combination of shells, point and plunger is then driven to refusal by means of an ordinary heavy

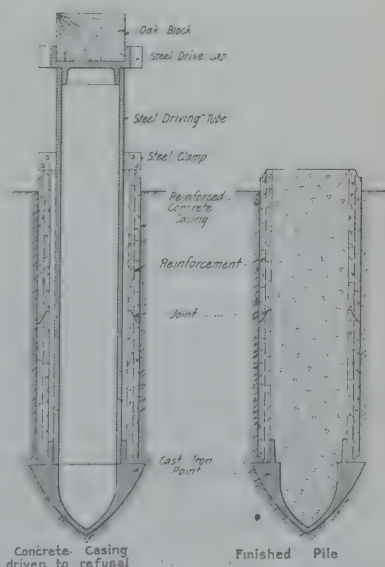


FIG. 33. PEERLESS PILE.
(Built in place.)

pile driver. It will be seen that the steel point receives the direct driving impact which is transmitted by the plunger and that the concrete shells are merely followed down without being called upon to take any strains other than those necessary to overcome their own surface friction against the surrounding soil. The maximum section of the cast-steel shoe is of a slightly larger diameter than that of the concrete shells, so that the former produces all of the displacement in the soil, while the opening made by it, being slightly larger than the shell, minimizes the amount of surface friction against the latter. When the shells have been thus driven, the plunger is withdrawn and the hollow interior of the shells filled with concrete. The reinforced concrete shells serve the purpose of a driving tube and also eventually form a part of the pile itself. This type of pile has not been used to an extent which would warrant an expression as to its relative advantages or disadvantages. It would seem that in the case of a water-bearing soil, trouble might occur from infiltration of ground water through the several joints between successive shells. There would appear to be no good reason, however, why these joints should not be made reasonably water tight by the insertion of some form of water-tight gasket. It also seems likely that the cost of preparing the shells might render such piles uneconomical in comparison with other available types. The general principles utilized, however, appear to offer some advantages over other built-in-place types. There is no lost time in pulling shells, neither is the concrete required to be elevated during the process of filling, as in the case of the two previously mentioned types. It is possible to inspect the interior at all times during the filling, and ample strength is provided by the shells against distortion due to lateral pressure. Generally speaking, it will also be possible to construct piles of a greater depth by this method than with the "Simplex" or "Pedestal" types, in which the difficulty of withdrawing the tubes limits the possible length of the pile to not over 50 ft. In the case of the "Peerless" pile, it is only necessary to use a plunger of sufficient length and to build up sections of shell to the extent required.

Tubular Piles.

Tubular piles have been used for a great many years for various purposes, but their use did not become common until fifteen or twenty years ago, when they were introduced to a considerable extent for the solving of some foundation problems in the city of New York. This use seems to have originated in the patented method adopted by Breuchaud in 1896, wherein he utilized them in the underpinning of buildings in and about New York City. The process consisted of cutting a narrow, vertical breach in the masonry of the building wall and inserting in this slot a short section of 12-in. steel tube, which was then forced vertically into the ground by means of hydraulic jacks of 60 to 100 tons capacity, reacting against short horizontal girders built in the masonry above them. Successive sections of double strength 12-in. pipe were coupled together so as to extend the length of tube until it finally reached hard bottom. The earth was then washed from the interior of the tube and concrete deposited until the pipe was filled. Bearing plates were adjusted at the top of the pipe and the load of the building transferred to them. The usual progress made by this method was about one foot per hour.

Later on, the use of "Tubular" piles became common in the construction of foundations for new buildings. In general, the method has been to drive these piles in sections sometimes to a total depth exceeding 100 ft., or until they reached ledge, and to insert therein steel rods which were incased in the concrete filling of the tube and rested at their lower extremity upon the ledge. It has been customary in New York City, where this method has been extensively employed, to figure these piles as columns fully supported laterally, with an allowance of 500 lbs. per sq. in. on the concrete section and 6 000 per sq. in. on the cross-sectional area of steel, including that of the pipe itself. The steel rods used for this purpose are usually 2 to $2\frac{1}{2}$ in. in diameter, and as many as 117 tons have been supported upon a single 12-in. tubular pile 70 ft. in length. The tube employed for this purpose is usually 12 in. in diameter and $\frac{3}{8}$ in. in thickness. In order to transmit the enormous load carried, it is necessary to square carefully the abutting ends of successive

sections of pipe and reinforcing rods, and, in order to avoid excessive external friction during driving, interior sleeves are adopted (Fig. 34). Heavy pneumatic hammers are usually

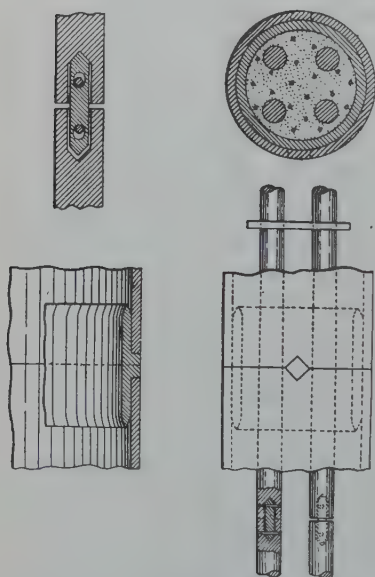


FIG. 34. SPLICES IN STEEL TUBES
AND REINFORCING RODS FOR
TUBULAR PILES.

employed in the driving of the piles, being handled by construction derricks. When the tube has finally reached ledge, its interior is thoroughly washed out by means of a strong water jet, but frequently in later practice by a stream of high-pressure compressed air which often proves more efficient in removing all soil from the interior of the pipe.

It is sometimes urged against the use of "Tubular" piles, or other types having a permanent steel casing, that the steel pipe will ultimately be destroyed by rust. The writer has been interested in this subject for a great many years, and has reached the conclusion, after observing the condition of hundreds of

specimens of steel and iron embedded in the soil for long periods, that there need be no apprehension of trouble from this source. The oxygen needed for the rusting process is to a very considerable extent excluded from the soil, and even though there be a sufficient amount to produce some oxidation, the first layer of rust which forms being prevented by the surrounding earth from dropping off, serves as a protection to the remainder of the metal against any progressive rusting action. It will almost invariably be found, where wrought steel or cast iron is uncovered after several years' burial in the ground, that the outer layers of rust have amalgamated with the adjacent soil and have formed what is equivalent to a rust joint which thoroughly protects the body of the metal.

Compressol Piles.

The "Compressol" pile, Fig. 35, is of French origin and has enjoyed a considerable use on the European continent. It has been little used in this country, however, although it was introduced in 1913 at Perth Amboy, N. J., in the construction of some building foundation work at that place. The process consisted in elevating a massive conical-shaped weight, 8 ft.

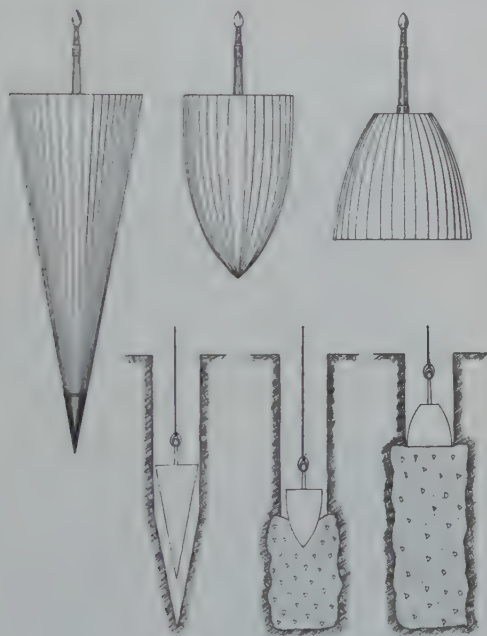


FIG. 35. COMPRESSOL PILE.
(Built in place.)

long and 3 ft. in diameter, weighing $2\frac{1}{2}$ tons, with its point suspended downward. This weight is then dropped so as to penetrate the ground at the point where the footing is to be constructed. Successive blows by this instrument eventually produced a cavity which extends to the desired depth or bearing stratum. If the material constituting the particular soil is

water bearing, clay and cinders are dumped into the cavity and rammed by the succeeding blows into the surrounding soil so as to render it impervious. When the desired depth has been reached, concrete is deposited in the bottom of the cavity and by means of a somewhat more rounded tool with an olive-shaped point, weighing about 2 tons and similarly used, the concrete is expanded laterally into the surrounding soil, giving a spread to the footing. Eventually the entire cavity is filled in this manner, leaving an irregular-shaped column of concrete in the soil. Large rocks are often used to consolidate the concrete mass and to assist in displacing the surrounding soil. While this process is apparently a simple and economical one, it suggests many elements of uncertainty as to final dimensions and conditions of the resulting pile. Nevertheless it may be well suited for many temporary purposes where the element of cheapness is paramount to that of known efficiency.

Wilhelmi Pile.

Another type of pile little heard of in this country is the "Wilhelmi" pile, Fig. 36. This pile is of French invention



FIG. 36. WILHELMI PILE.
(Built in place.)

and resembles very closely the "Pedestal" pile in final result, except that the bulb chamber is formed by exploding a charge of dynamite in the lower portion after the tube has been driven.

The Caisson Pile.

The "Caisson" pile, Fig. 37, appears to have originated in Chicago in the year 1893. In reality it can hardly be classed as a pile, but resembles more closely an ordinary pier footing except that the excavation is made to the exact dimensions of the pier, and concrete forms, therefore, are not required. The excavation is circular in cross-section and of sufficient area to support the pier load in compression. This circular excavation is carried down to good bottom, the walls of the excavation being lined in short sections by wooden staves held in place by interior rings. When satisfactory bottom is reached, the excavation is enlarged in the shape of a frustum of a cone, so that the load may be safely distributed over a sufficient area. The excavation is carried on by the pick-and-shovel method, small-sized buckets being used to elevate the earth as it is loosened. When the excavation is completed, the bottom may be inspected and concrete then deposited, first filling the footing chamber and later the circular shaft. The sections of wooden lining, together with their supporting rings, are removed as the concrete filling progresses, so that the final construction results in a circular concrete column resting upon a spread footing and capable of supporting safely a total pier load of an amount depending upon the dimensions of the shaft and footing. It is possible for a man to excavate within the limits of a 3-ft. diameter shaft.

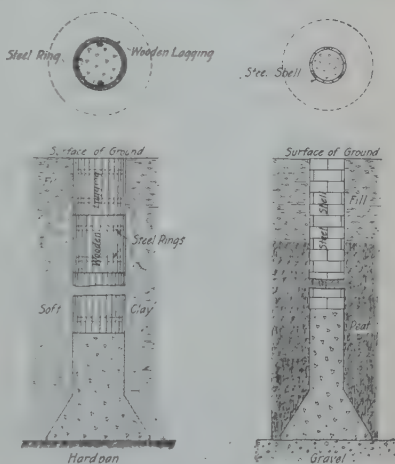


FIG. 37. CAISSON PILE.
(Built in place.)

This shaft when filled with concrete is capable of supporting a 250-ton load, using a unit compressive value on the concrete of 500 lbs. per sq. in. If loads in excess of this amount are to be applied, the diameter of the circular excavation must be increased accordingly. The area of the base of the enlarged footing must be made sufficiently greater than that of the shaft to distribute the total load safely upon the supporting soil. This method has been used in the soft Chicago clays to depths of 80 ft. or more. Oftentimes it becomes necessary, in passing through water-bearing sands and other unstable soils, to use a light vertical shield which retains the shape of the hole while the wooden lining is assembled inside of its protecting shell. In some instances it becomes necessary to adopt the pneumatic process in the sinking of these piles, in order to penetrate troublesome material. The writer has had occasion to use this system to a considerable extent in the vicinity of Boston, Mass. On account of the prevalence of water-bearing strata in that district, the temporary lining adopted has generally been of steel cylinders, either driven in lengths or made sectional and bolted together.

Wherever considerable loads are to be supported at given points, the "Caisson" pile will usually be more economical than equivalent clusters of individual concrete piles. Generally speaking, however, this does not apply to loads under one hundred tons. It is not possible to construct "Caisson" piles under all conditions, and, therefore, clusters of individual piles may frequently be necessary in any event. Since the "Caisson" pile usually rests directly on top of the bearing soil stratum, its length is materially less than that of driven piles for the same location, which necessarily must enter a sufficient distance into the bearing soil to develop the necessary frictional resistance.

COMBINATION PILES.

Various combinations of concrete and wood piles and of pre-cast and built-in-place piles have been used under special circumstances. Tubes driven by the "Simplex" method are sometimes utilized to receive pre-cast piles which are merely

inserted inside the tube after the latter has been driven and a small amount of concrete deposited above the point. The pre-cast pile is forced into this fresh concrete, and grout is poured into the space between the pile and the tube. The tube is then withdrawn in the usual manner. This arrangement avoids the necessity of subjecting the pre-cast pile to any driving strains and prevents any distortion of the pile when the tube is pulled.

An interesting instance of combining the two systems is reported in the case of the 25-in. diameter concrete piles for the Atlantic City Music Hall Pier. These piles were cast with bulb-shaped footings $3\frac{1}{2}$ ft. in diameter, and were sunk into place through the sand by the jetting process. In order to avoid the handling of such extremely heavy piles, only the bulbs and a short length of the stem were pre-cast, the reinforcing rods, however, projecting for their full length. A light steel shell of 25-in. diameter surrounding the reinforcing rods was attached to the pre-cast portion of the pile and the joint with it made water tight. After the footing with the attached shell had been jetted into place, the remainder of the pile was cast in place by merely filling the shell.

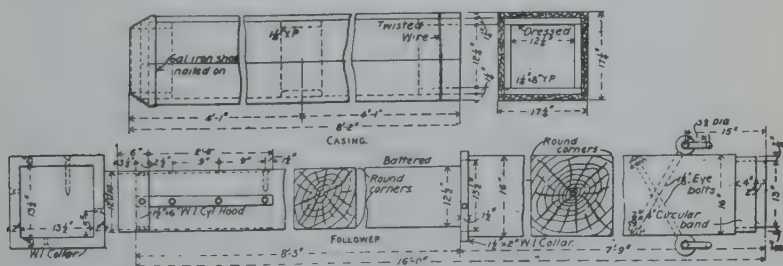


FIG. 38. FORM AND BOX FOLLOWER FOR COMBINATION WOOD AND CONCRETE PILE.

In the construction of the Delaware, Lackawanna & Western Hoboken Terminal, in 1905, the station platforms were supported upon wooden piles whose tops were driven 8 ft. below grade by the following means. (Fig. 38.) A square box consisting of 2-in. planks 8 ft. long was constructed upon the head of

each pile. A wooden follower was inserted through this square box and rested upon the head of the pile. By means of a collar near the top of the follower, the square box was driven into the ground with the pile. The follower was then withdrawn and the box filled with concrete, thus insuring safety against decay of the wooden pile heads.

In another instance, hollow steel pipes surrounded wooden pile heads and permitted the entrance of a follower so that the pile head might be successfully driven below the water level, after which concrete was deposited inside of the pipes.

Wooden piles for wharves and piers have often been driven in the usual manner, and the top portion standing in the water surrounded with concrete shells, the intermediate space being filled with grout or concrete.

The "Ripley" pile, so called, consists of a wooden pile wrapped with a metal mesh and concrete so as to form a concrete pile with a wooden core.

Some simple expedients are frequently resorted to in special cases where economical considerations preclude the adoption of more elaborate or expensive types. For example, common auger borings up to 15 in. in diameter have been successfully made in gumbo soils and the resulting hole filled with concrete, thus forming a reasonably satisfactory type of concrete pile for moderate loads. In another instance, grouting the underlying soil was resorted to, working from the bottom upward, thus consolidating a column of otherwise unsatisfactory soil immediately under the load.

Still another method of securing concrete pile foundations has been to build and jet the piles simultaneously, using very light sheet-steel shell sections of No. 20 gage, telescoped together similar to ordinary stove piping, a 1½-in. jet pipe being introduced in the center and the shell filled with concrete. By applying the jet pressure, the soil is washed away in advance of the pile, which drops into the cavity from its own weight. The writer has sunk piles to a depth of 80 ft. by this process, in fine sand and silt.

SELECTION OF TYPE OF PILE.

The determination of the particular type of concrete pile which should be adopted for a given case usually presents more or less difficulty. The problem may generally be solved, however, by a careful consideration of all the factors physical and economical which enter into the situation.

In the construction of wharves, docks and other works of a class which requires that a portion at least of the pile length shall stand in or above a body of water, the choice ordinarily will be limited to the pre-cast type of pile (Figs. 39, 40, 41 and 42). In a congested locality in the heart of a busy city, on the other hand, where construction space is not readily available, the built-in-place type of pile will be more likely to answer the requirements of the case.

Similarly, if it is necessary, because of important considerations, to commence construction operations immediately, and especially if there be no satisfactory means available for curing the piles by steam, it will usually be advisable to abandon the pre-cast pile suggestion because of the prohibitive length of time which must elapse after their manufacture and before they can be handled and driven.

The use of the pre-cast pile is often undesirable when there is not readily available a sufficient source of water supply to furnish an adequate volume for the jetting process. The amount of water used in jetting piles is, in the aggregate, considerable. From 100 to 200 gals. per minute is probably not an excessive estimate of the quantity of jet water required in sinking piles by this method, and, where such volumes of water are not at hand, economical considerations may suggest the adoption of built-in-place piles in preference to those which require jetting.

Sometimes it is necessary to drive only a comparatively small number of concrete piles for a given purpose, in which case the expense of transporting, erecting and removing the extremely heavy driving apparatus necessarily employed with built-in-place piles will render the cost of such a small group prohibitive. In such cases pre-cast piles may be driven or jetted with the aid of the construction derrick, utilizing a steam hammer suspended from the derrick boom, or a small

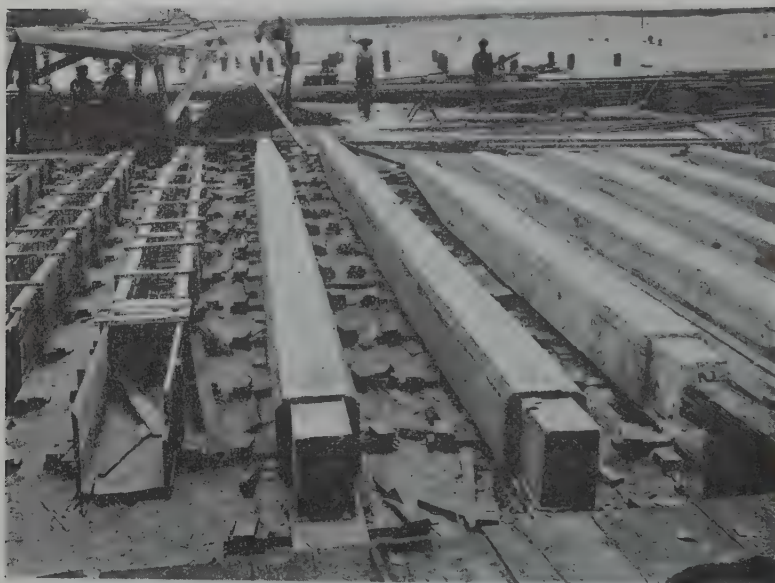


FIG. 39. PRE-CAST PILES FOR WHARF.



FIG. 40. WHARF CONSTRUCTION ON CONCRETE PILES.



FIG. 41. WHARF CONSTRUCTION AT CHARLESTON, S. C.



FIG. 42. WHARF CONSTRUCTION AT CHARLESTON, S. C.

timber driving frame (Fig. 43) may be employed. Where there are but a few piles required for a given installation, the writer has frequently recommended the use of light tubes in the form of second-hand wrought-iron pipe driven into the ground by some simple apparatus, after which they may be washed out and filled with concrete, leaving the wrought-iron shell as a component part of the pile. This, of course, is merely an adaptation of the tubular pile previously described.



FIG. 43. PILE BEING DRIVEN WITH AID OF CONSTRUCTION DERRICK AND TIMBER-DRIVING FRAME.

If it is deemed desirable to adopt the pre-cast type of pile, the particular conditions surrounding the work may suggest the adoption of one or another of the patented types of pre-cast piles, although in general any type of pre-cast pile can successfully be driven if proper facilities are available. If the material through which the pile is to be driven is of a nature which renders jetting more or less ineffective, recourse must be had to long-continued hard driving. In such a case, a pile of the "Cum-

mings" type probably offers as good a solution as can be found, especially for long lengths of pile. The "Giant" pile also is obviously well suited for such a condition, although it seems probable that its use must be limited to lengths not exceeding 25 to 30 ft. In situations where the use of the hammer is difficult, expensive or inconvenient, the "Bignall" type of pile may offer a solution, relying upon the jetting process only. In any of these cases, an unpatented type of pile may be designed and driven with the use of proper cushion caps and hammers so that final results may be equally satisfactory. The question involved, therefore, is merely one of relative economy.

With regard to the several types of built-in-place piles, it seems reasonably clear that those types which leave their shells permanently in place, such as the "Raymond," "Peerless" and "Tubular" piles, offer a somewhat better guarantee of the final and continued integrity of the completed pile. The use of the "Raymond" pile, however, should probably be limited, as previously suggested, to those cases in which a substantial portion of the length of pile will rest in firm soil in order that too great a proportion of the load will not have to be carried on the small sectional area near the point. These three types of piles may also be driven to greater depths than other types of built-in-place piles for the reason that there is no tube to be withdrawn, a process which requires enormously powerful tackle and lifting apparatus, especially when the length of tube is great.

In the great majority of cases, however, built-in-place piles of the "Simplex" and "Pedestal" type may be used with perfect safety and oftentimes with decided economy. It seems probable to the writer that in soils which are definitely and permanently compressible, such as peat, silt and rubbish filling, there is little likelihood of a subsequent reaction of a nature which will cause damage to the piles. On the other hand, it appears reasonably conclusive that some of the clays, sands and gravels are decidedly elastic in character under certain conditions, and that the resultant action due to driving piles into them is one of displacement laterally rather than of simple compression. This displacement apparently sets up elastic

forces of considerable amounts which react against the soft concrete after the protecting tube is withdrawn, tending greatly to displace and deform the concrete sections and also to disturb the adjacent piles, previously driven, because of the lateral motion imparted to the surrounding soil. When this type of pile is used in soil which is not known to be positively compressible, it will be well to avoid driving successive piles within six feet of one another. This requirement undoubtedly places a considerable economic burden upon the driving contractor because of the greater amount of machine moving required. Nevertheless, unless actual inspection may be had of test piles driven at closer intervals and indicating an entire absence of damage by deformation, the owner is not justified in sanctioning the more economical procedure.

Where heavy concentrated pier loads are to be carried on piles, it will usually be well to give consideration to the possible adoption of the "Caisson" pile method. In order that this type should be applicable to a given case, the soil at the base must be of a nature which will permit chambering in the shape of a frustum of a cone, and this implies a considerable degree of firmness and cohesion between the particles constituting the soil. There will usually be no difficulty in chambering enlarged footings in dry clay, stiff mud or peat. This method will obviously be impracticable in a loose soil such as sand, gravel or semi-fluid mud. This type of pile will usually not be economical in comparison with other types for loads less than one hundred tons each.

It is probable that the combination wood and concrete pile might more often be used than is customary. Where the conditions impose only a very moderate load upon each pile, and when large numbers of piles are required in the aggregate, a very considerable economy will result if the wooden pile is used in conjunction with a hollow pipe or box follower, so as to permit the head of the wooden pile to be driven below ground water level while the follower portion is filled with concrete.

MEMOIR OF DECEASED MEMBER.

LORENZO GORDON MOULTON.*

LORENZO GORDON MOULTON was born in Beverly on February 7, 1848, being the eldest son of Eben H. and Irene (Conant) Moulton. He was a direct descendant of the early New England settlers, descending on his father's side from Robert Moulton, who was sent to Salem from England by the Home Company in 1629, with orders to begin shipbuilding, and on his mother's side from Roger Conant, who came to New England in 1623.

He attended the Beverly public schools, usually leading his class, and graduated from the High School at the age of fifteen.

Two years later he left home to learn the pattern maker's trade at Boston, his first job being with Spaulding and Coffin. Later he went to New Jersey, where he worked a year, on his way back to Boston making a walking tour of the Pennsylvania iron regions and trying to acquaint himself with every phase of the iron business.

In '73 he entered the employ of the G. W. and F. Smith Company, with which he remained, with the exception of a year or two, up to 1915, at first serving as foreman of the pattern shop, then as mechanical engineer.

Mr. Moulton was of a studious nature and found time, in addition to the study necessary for his profession, for wide reading on many other subjects. He was a deep student of Latin, French and German, and was a botanist of no mean order. His fund of general information was remarkably large, it being proverbial among his associates that about doubtful questions "Moulton would know." As a mathematician he was rapid and accurate, and he was particularly successful in solving the intricate problems connected with the alteration and reconstruc-

* Memoir prepared by L. L. Street.

tion of buildings. Many visible examples of his skill along these lines may be seen in Boston and are well known to his associates.

He became a member of the Boston Society of Civil Engineers on April 16, 1913. He was a member of the Masonic fraternity, being affiliated with Liberty Lodge of Beverly. He was married and left one daughter, now living in Boston.

He died on June 9, 1915.

BOSTON SOCIETY OF CIVIL ENGINEERS

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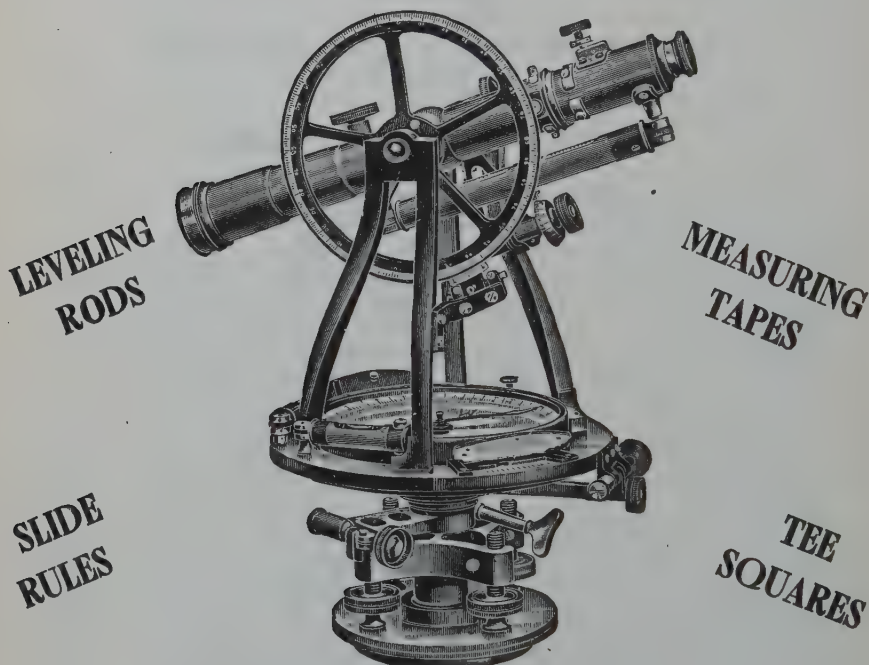
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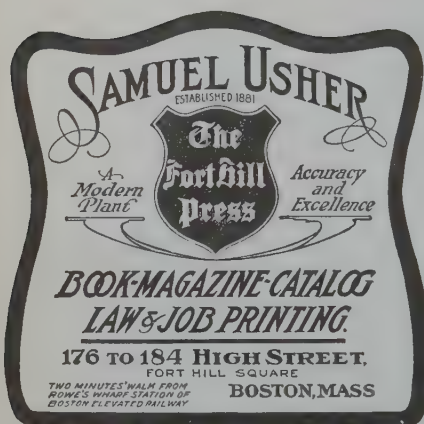
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